TIGERS IN A MULTI-USE FOREST:

PREY, DIET AND CONFLICT

A thesis submitted by

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Dedicated to the Sitabani Male

"Tiger ke aankhon ke siwa duniya mein rakha kya hai."

— Professor Qamar Qureshi

DECLARATION

I hereby declare that the work conducted under the thesis entitled **“Tigers in a multi-use forest”,** is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Master’s in Wildlife Science** at the **Academy of Scientific and Innovative Research**. This research work has been carried out under the guidance and supervision of **Dr. Bivash Pandav**, **Scientist G**, and co-supervision of **Dr. Bilal**, **Scientist F** of Wildlife Institute of India, Dehradun. The work has not formed the basis for the award of any other degree, diploma, or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.

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Executive Summary

This study provides a comprehensive assessment of tiger prey, dietary dynamics, and human-wildlife interactions in the Ramnagar Forest Division, a critical area outside protected areas in the Western Terai Arc. Despite a notable increase in tiger numbers—from 39 adults in 2015 to 67 in 2022—density surface modeling revealed persistently low populations of key wild prey species such as chital and sambar, primarily due to habitat degradation from historical timber-focused management. Diet analysis of genetically confirmed tiger scats demonstrated a strong reliance on large-bodied prey, with sambar and livestock comprising a significant portion of tiger biomass intake, reflecting both prey scarcity and ecological stress. The detection of plastic in both sambar and tiger digestive tracts further highlights the emerging threat of environmental pollution in multi-use forests. Human-tiger conflict remains acute, with 353 livestock depredation events and 28 attacks on people recorded over recent years, concentrated near settlements where prey and livestock overlap are highest. These findings underscore the urgent need for integrated conservation strategies that prioritize habitat restoration—such as grassland recovery—community-based conflict mitigation, improved waste management, and a shift in forest policy from timber production to biodiversity and coexistence. Only through such landscape-level, participatory approaches can the long-term viability of tigers and their prey be secured in shared, human-dominated areas like Ramnagar.

Introduction

Large carnivores as the apex predator help regulate prey and mesopredators populations, stabilizing food webs and maintaining biodiversity (Beschta & Ripple,2009). Their presence influence vegetation dynamics, soil nutrient cycles, and overall ecosystem productivity (Morris & Letnic,2017). But in recent decades, their populations have faced a significant decline due to habitat fragmentation, human persecution, prey depletion, and other anthropogenic pressures (Crooks,2011, Wolf & Ripple, 2016). This decline has triggered cascading effects – like overpopulation of herbivores or vegetation changes in all the ecosystems they are part of. However, recovery efforts for large carnivore population have shown promising results in recent years, conservation interventions have helped restoring the ecosystems. A well-known example being the reintroduction of wolves which helped revive riparian ecosystems by keeping herbivore and mesopredator numbers in check (Wolf & Ripple, 2016).

In Global South, where people live close to nature, recovering large carnivore populations is tough. Conservation debates often center around 'land sparing' – keeping people and predators apart. Many argue that sharing space with predators is not practical because overlap may only intensify conflict. Tiger recovery in India necessitated a mix of both land sharing and land sparing – protecting core areas and allowing coexistence in shared landscapes to ensure connectivity. (Jhala, 2025).

In India, where human population density is among the highest globally and forests face constant pressure, tigers, leopards, and even lions continue to persist. Even as agriculture and infrastructure are spreading rapidly, fragmenting their habitats, these carnivores have held on. Although tigers faced a global decline across its known ranges over the past century. This majestic big cat has vanished from more than 90% of its historic range. Still tiger recovery in India comes as a ray of hope as India successfully met the Global Tiger Recovery Program's ambitious target to double its tiger population. India now hosts approximately 75% of the world's wild tigers, with a 30% (at 2,929 square kilometers per year) increase in tiger occupancy, leading to the largest global population occupying ~138,200 square kilometers (Jhala, 2025).

Studies across the globe has shown that large carnivores frequently use areas beyond protected area boundaries-including edge habitats and agricultural fields - even when these landscapes present elevated mortality risks (Balme, 2010; Warrier, 2020). Similarly, about one-third of India’s tiger population inhabits areas outside protected areas. These non-protected landscapes are mostly multiuse forests with high levels of human activity such as intensive operations such as mining, logging, and other forestry practices, day-to-day activities like firewood and fodder collection, and livestock grazing. This human presence increases the likelihood of encounters with large carnivores, potentially leading to negative interactions.

Human-wildlife conflict, particularly involving tigers and leopards, poses significant challenges in regions where human settlements are surrounded by their habitats. A major source of conflict arises from livestock depredation, as rural communities often rely heavily on livestock for their livelihoods. In India, both tigers and leopards are responsible for substantial livestock losses—while tigers may target larger animals like cattle, leopards, due to their adaptability to human-modified landscapes, frequently prey on smaller livestock such as goats (Lamichhhane, 2023; Majgaonkar, 2024; Dahya, 2021).

These losses often provoke retaliatory killings, which pose a serious threat to big cat populations. In fact, conflict-related mortalities are believed to be the second leading cause of human-induced tiger deaths after poaching (Goodrich,2010). Moreover, such conflicts foster negative attitudes among local communities, reducing support for conservation efforts and undermining long-term coexistence (Hasan, 2023; Tekalign, 2016; Bargali, 2018). While livestock losses are the most common trigger, human casualties further intensify tensions.

Recent studies have shown that tigers can maintain high densities in human-dominated areas, provided there are sufficiently high prey densities and patches of refuge habitats, especially in areas with dense vegetation and low human disturbance (Chanchani, 2024). However, these landscapes also experience frequent human–tiger conflicts, posing risks to both human life and livestock. To effectively conserve tigers in a country like India, it is crucial to focus on habitats outside protected areas, a domain where research has traditionally been sparse. Our current understanding of tiger prey selection and preferences is largely based on studies within protected areas, which suggests that while tiger diets are often dominated by numerically abundant prey, tigers preferentially select larger-bodied species like sambar when prey availability is considered and in absence of large bodied wild prey, livestock is preferred. Moreover, prey selection can vary with terrain, forest type, and even the level of human disturbance. The protection of core tiger source populations has enabled their persistence in multi-use landscapes (land sharing), but to ensure the long-term viability of these populations, it is essential to deepen our understanding of their prey, dietary habits and conflict in these areas and to address issues related to livestock depredation

Background

The dynamics between tigers (Panthera tigris) and their prey has fascinated observers for millennia, from the earliest Chinese texts such as the *Shanhaijing* (c. 300 BCE), which described tigers preying on deer and wild boar, to the Junagadh Rock Inscriptions (c. 150 CE) in India, which recorded tigers as a menace to livestock. Early travelers, monarchs, and later, colonial hunters and naturalists like Arthur Locke, all documented their observations of tiger diet and conflict, were largely anecdote of chance observations. It was not until the pioneering scientific work of George Schaller in Kanha, culminating in his book *The Deer and the Tiger*, that systematic, ecological studies of tiger-prey dynamics began to shape our understanding of this apex predator's role in various landscapes.

Multi-use Forest

While, protected areas—such as national parks and wildlife sanctuaries—are established under the Wildlife (Protection) Act, 1972, with the primary aim of conserving biodiversity and wildlife habitats. These areas are managed with strict restrictions on human activities: timber extraction, commercial exploitation, and even grazing are generally prohibited to maintain ecological integrity and prioritize conservation over resource use. Multi-use forests in India, as recognized under the Indian Forest Act, 1927, primarily include reserved forests and village forests. These forests are legally designated and managed for a range of objectives, notably the sustainable extraction of timber and other forest produce, grazing, and supporting local livelihoods, alongside conservation goals (Rangarajan, 1996; Stebbing, 1926). In these forests, regulated human activities such as timber harvesting, collection of non-timber forest products, and controlled grazing are permitted under working plans, reflecting a utilitarian approach to forest management (Rangarajan, 1996). Assisted Natural Regeneration (ANR) is a widely used silvicultural practice in these forests, which involves the protection and nurturing of naturally occurring seedlings by controlling disturbances like grazing and fire. This approach accelerates forest recovery and supports sustainable timber production, aligning with the multi-use mandate of these forests.

Tiger Diet

During the Pleistocene era, when climate of the earth underwent periodic fluctuations between the Glacials and Inter-glacials periods with forested regions shrinking and grasslands expanding during the Glacial periods and forests expanding and grasslands shrinking during the Inter-glacial periods throughout the entire Asia, numerous forms of large ungulates such as the deer family (*Cervidae*), antelopes and cattle (*Bovidae*) and wild pigs (*Suidae*) evolved and took over the entire continent. Tigers evolved and radiated as hunter of these ungulates filling the niche of a large bodied forest edge predator (Sunquist 1999).

Although Tigers are known to eat a variety of prey ranging in size from termites to elephant calves, their survival is primarily linked to the large-bodied prey. Early accounts and colonial-era documentation often noted tigers preying on large wild ungulates and, in areas of human settlement, livestock. Scientific studies, beginning in the mid-20th century, have since confirmed that tigers preferentially hunt prey species similar in body mass to themselves, a pattern consistent with all its subspecies (Allen, 2020; Linda, 2015; Karanth & Sunquist, 1995; Biswas, 2023). This preference provides an optimal forage which helps them get the most energy while avoiding unnecessary risk of injury. This behavior likely evolved to maximize their survival and efficiency.

Studies across tiger range countries have shown that tigers select for large-bodied prey, such as sambar (Rusa unicolor), wild boar (Sus scrofa), and, where present, gaur (Bos gaurus) or buffalo (Bubalus bubalis) (Allen, 2020; Kerley, 2015; Navaneethan, 2019). In the Russian Far East and Hunchun China, wild boar, roe deer and red deer collectively make up most of the Amur tiger’s diet, while in the Indian subcontinent, sambar and chital are similarly dominant (Gu, 2018; Upadhyaya, 2018; Harihar, 2011).

Early studies by Karanth and Sunquist (1995) in Nagarahole, India, established that sambar (Rusa unicolor), chital (Axis axis), and wild boar (Sus scrofa) are the most frequently consumed and preferred prey, a pattern confirmed in subsequent meta-analyses and field studies across Asia (Hayward, 2012). In the Russian Far East, Amur tigers show a strong preference for wild boar, which constitute the bulk of their diet, as confirmed by both scat and kill data (Kerley, 2015; Sugimoto, 2016). Sambar and wild boar similarly rank as the most preferred prey for Sumatran tigers, studied through spatial and temporal overlap using camera trap data (Allen, 2021). Scat analysis in Nepal's Parsa National Park revealed that while chital were the most frequently killed, sambar provided the greatest biomass, with an average prey weight of 138 kg, which highlights the importance of large-bodied prey for tiger (Lamichhane, 2022).

Research in Bardia National Park, Nepal, also supports these findings, with tigers mostly preying on wild species and showing minimal livestock predation, indicating that healthy wild prey populations can buffer against human-tiger conflict (Kumar., 2020). In multi-use forests, like the Begur Range in southern India, tigers still demonstrate a preference for wild prey where available, but the composition may shift in response to local prey densities and human activity (Ambili, 2023). Studies in the Sundarbans mangrove forests of India and Bangladesh have shown that tigers adapt to local prey communities, mostly consuming spotted deer, and wild pig, with spatial variation reflecting prey availability (Barlow, 2009; Chakrabarti, 2016).

Meta analysis (Hayward, 2012) suggests that tigers following an optimal foraging strategy (Goss-Custard, 1977; Krebs, 1980), like other solitary predators, maximize their energetic returns by targeting prey within a preferred weight range (typically 60–250 kg), which is like the observed dominance of sambar, wild boar, and similar-sized species in their diets. This preference is reinforced by the tiger's hunting strategy, which is adapted for ambushing large, often solitary, or small-grouped prey rather than coursing after herding species (Creel & Creel, 2002).

Recent studies have refined our understanding of prey selection by integrating spatial and temporal overlap metrics from camera trap data, revealing that high encounter rates with preferred prey species are critical for tiger persistence (Allen, 2021; Ngoprasert, 2012). In multi-use forests, prey availability is often reduced due to human activities such as livestock grazing and hunting, leading to shifts in tiger diet and increased livestock predation when wild prey densities fall below critical thresholds (Karanth, 2004; Harihar, 2014). However, even in these landscapes, tigers show a marked preference for wild prey over livestock when both are available (Kumar, 2020; Lamichhane, 2022).

The relationship between tiger density and prey biomass has been documented in various landscapes, with higher prey abundance supporting greater tiger densities and reducing the likelihood of conflict (Karanth, 2004; Hayward, 2012). Studies in the buffer zones of Indian reserves have shown that sub-adult and male tigers are more likely to prey on livestock, particularly where wild prey is depleted and livestock densities are high (Bargali,, 2018). In contrast, in well-managed protected areas with robust wild prey populations, livestock rarely feature in tiger diet (Lamichhane, 2022; Karanth & Sunquist, 1995).

Comparative studies across tiger subspecies and regions, including the Amur tiger in Russia (Keller, 2015), the Sumatran tiger in Indonesia (Allen, 2021), and the Bengal tiger in India and Nepal (Karanth & Sunquist, 1995; Lamichhane, 2022; Kumar, 2020), consistently demonstrate the centrality of wild ungulates-particularly sambar, wild boar, and in some regions, deer species such as chital and red deer-to tiger ecology. These findings are supported by meta-analyses and reviews

(Hayward, 2012; Sunquist, 1999) and are critical for informing conservation strategies in both protected and multi-use landscapes.

Human Tiger Conflict

Human-tiger conflict (HTC) is a complex and persistent conservation challenge that arises wherever tiger habitats overlap with human-dominated landscapes, and its dynamics are shaped by ecological, socio-economic, and cultural factors across Asia. Historically, tigers have been responsible for more human fatalities than any other large cat, with most attacks occurring in regions like India, Bangladesh, Nepal, and Southeast Asia (Goodrich, 2010; Barlow, 2009; Chakrabarti, 2016). The Sundarbans mangrove forests, spanning India and Bangladesh, are notorious for high levels of human-tiger conflict, with a record of 1,000 people killed by tigers on the Bangladesh side since 1950 and annual averages of 23 deaths since 1989, mostly among fishermen and local communities collecting forest produce (Chatterjee, 2001).

The primary drivers of HTC include livestock depredation, accidental encounters, and, in rare cases, habituated behavior of predating on humans. Cattle lifting is widespread, especially on the peripheries of reserves and in multi-use forests, with hundreds of livestock lost annually in areas like Melghat, Corbett, and Dudhwa (Karanth & Sunquist 1995; Karanth, 2004). The root causes of such conflict often lie in depleted wild prey populations, habitat fragmentation, and high livestock densities, which force tigers to target domestic animals (Sunquist, 1999; Karanth, 2004; Goodrich, 2010). Accidental attacks on humans typically occur when villagers enter forests for grazing, fuelwood collection, or non-timber forest products, and are most frequent in landscapes with high human use and fragmented tiger habitat (Barlow, 2009; Goodrich, 2010; Nyhus & Tilson, 2004; Inskip & Zimmermann, 2009).

Poisoning of carcasses, snaring, and shooting are common forms of retaliation, and these actions can have severe consequences for local tiger populations, especially in small or isolated reserves (Karanth & Sunquist, 1995; Karanth, 2004; Goodrich 2010). The expansion of tiger populations outside protected areas, while a conservation success, has also led to increased conflict as tigers traverse agricultural landscapes and human settlements in search of territory and prey (Karanth, 2010; Harihar, 2014).

Socio-ecological studies have shown that tolerance for tigers is influenced by factors such as the frequency of conflict, perceived risks, effectiveness of compensation schemes, and cultural attitudes toward wildlife (Inskip, 2016; Carter, 2012). Timely and adequate compensation for livestock losses, participatory management, and education are critical for reducing hostility and preventing retaliatory killings (Treves & Karanth, 2003; Dickman, 2010). Spatial modeling and risk mapping have been used to identify conflict hotspots and guide targeted mitigation efforts, such as the installation of predator-proof livestock enclosures, community vigilance programs, and the restoration of wild prey populations (Karanth et al. 2004; Goodrich 2010; Inskip et al., 2016).

Despite the challenges, many communities continue to coexist with tigers, and conflict mitigation has seen some success through integrated approaches that combine ecological restoration, improved livestock management, compensation, community engagement and technological advancements (Dickman 2010; Goodrich 2010). The future of human-tiger coexistence will depend on landscape-level planning, the maintenance of ecological connectivity, and sustained investment in both conservation and rural development (Sunquist, 1999; Goodrich, 2010; Inskip & Zimmermann, 2009). Thus, the literature underscores that human-tiger conflict is not merely a problem of wildlife management, but a socio-ecological challenge requiring interdisciplinary solutions and long-term commitment.

The dynamics of tiger diet and conflict shift dramatically in multi-use forests, where human activities such as livestock grazing, fuelwood collection, and agriculture intersect with wildlife habitat. In these landscapes, wild prey densities are often depressed due to hunting, habitat degradation, and competition with livestock in terms of forage. As a result, tigers may increasingly turn to livestock as a food source, particularly when wild prey become scarce.

A study in the buffer zone of Panna Tiger Reserve (Kolipaka, 2017), India, display this pattern: in areas with high livestock density and open-access grazing, sub-adult and male tigers killed more livestock than wild prey, even when wild prey was available. Seasonal patterns in livestock herding and proximity to the core protected area also influenced predation rates, with more livestock killed during the winter and monsoon seasons and at greater distances from the reserve boundary. These findings highlight the incompatibility of unregulated livestock grazing with large carnivore conservation in shared landscapes and underscore the need for improved livestock management by providing designated areas for grazing, limit the livestock number and community engagement.

Objectives

Objective 1: Model Spatial Density Distributions of Prey Species

Hypothesis:

Prey density will exhibit significant spatial heterogeneity, driven by habitat variables and human disturbance.

Objective 2: Assess Tiger Prey Selection and Foraging Preferences

Hypothesis:

Tigers will exhibit selective predation toward larger-bodied prey (e.g. Sambar) over smaller-bodied species.

Objective 3: Map Human-Wildlife Conflict Hotspots

2.1 Study Area - Ramnagar Forest Division, Uttarakhand

Location

Ramnagar Forest Division, located in the western part of Terai-Arc landscape in the state of Uttarakhand. Contiguous with the Shivalik's in the north and Gangetic plains in the south. River Kosi in the west forms it's western boundary with National Highway 309 separating it from the Corbett Tiger Reserve, similarly river Gola in the east forms it's eastern boundary.

Topography

Ramnagar Forest Division lies in the Shivalik Bhabhar belt characterized by hilly terrain with coarse soil and boulders in the north and small part of the area with fine alluvium and a shallow water table in the south. Elevation ranges between 307 and 1802 m. Other than Kosi and Gola, Dabka, Bor, Nihal and Bhakra are the other major rivers in the area along with hundreds of small bouldery streams.

Vegetation

RFD supports sal forest, mixed sal forest, mixed forest, teak plantation, scrubland, moist riverine forest, and dry riverine forest with sal forest being the dominant forest type (Ahmed, 2018). Vegetation is mainly comprised of sal (*Shorea robusta)* dominated forests and teak (*Tectona grandis)* plantations planted at most of the the grassland sites during 1991 (department records). Other important tree species in the corridor are bankuli (*Anogeissus latifolia*), bel *(Aegle marmelos*), ber (*Zizyphus* sp.), jamun *(Syzigium cumini)*, rohini (*Mallotus phillipensis*), and khoda (*Ehretia laevis*). Kuri (*Lantana camara*) dominates the forest as an exotic weed which is a major part of the under story but it is not preferred by the herbivores.

Management

Ramnagar Forest Division with a total area of almost 484 sq. kilometers is divided into 5 ranges namely Kosi Range, Kota Range, Dechauri Range, Kaladhungi Range and Fatehpur range which are further divided into 68 beats in total to effectively manage this forest. Assisted Natural Regeneration is a technique being widely employed all over the study area to secure timber availability for the future as per the working plan.

Van Panchayats

Van Panchayats in Uttarakhand are democratically elected village-level bodies that manage designated community forests, making rules for protection, use, and distribution of forest resources among villagers. While they share some features with Joint Forest Management (JFM), Van Panchayats are distinct—they function as autonomous local institutions with legal authority over specific forests, rather than as co-management partners with the forest department as in JFM. Their management includes regulating grazing, protecting against illegal felling, and ensuring equitable access to forest produce, with oversight and technical support from government agencies. Thus, Van Panchayats represent a unique, community-driven forest management system rather than a conventional JFM practice. Ramnagar Forest Division has 40 van panchayats in total with about 14 % of forest area allotted.

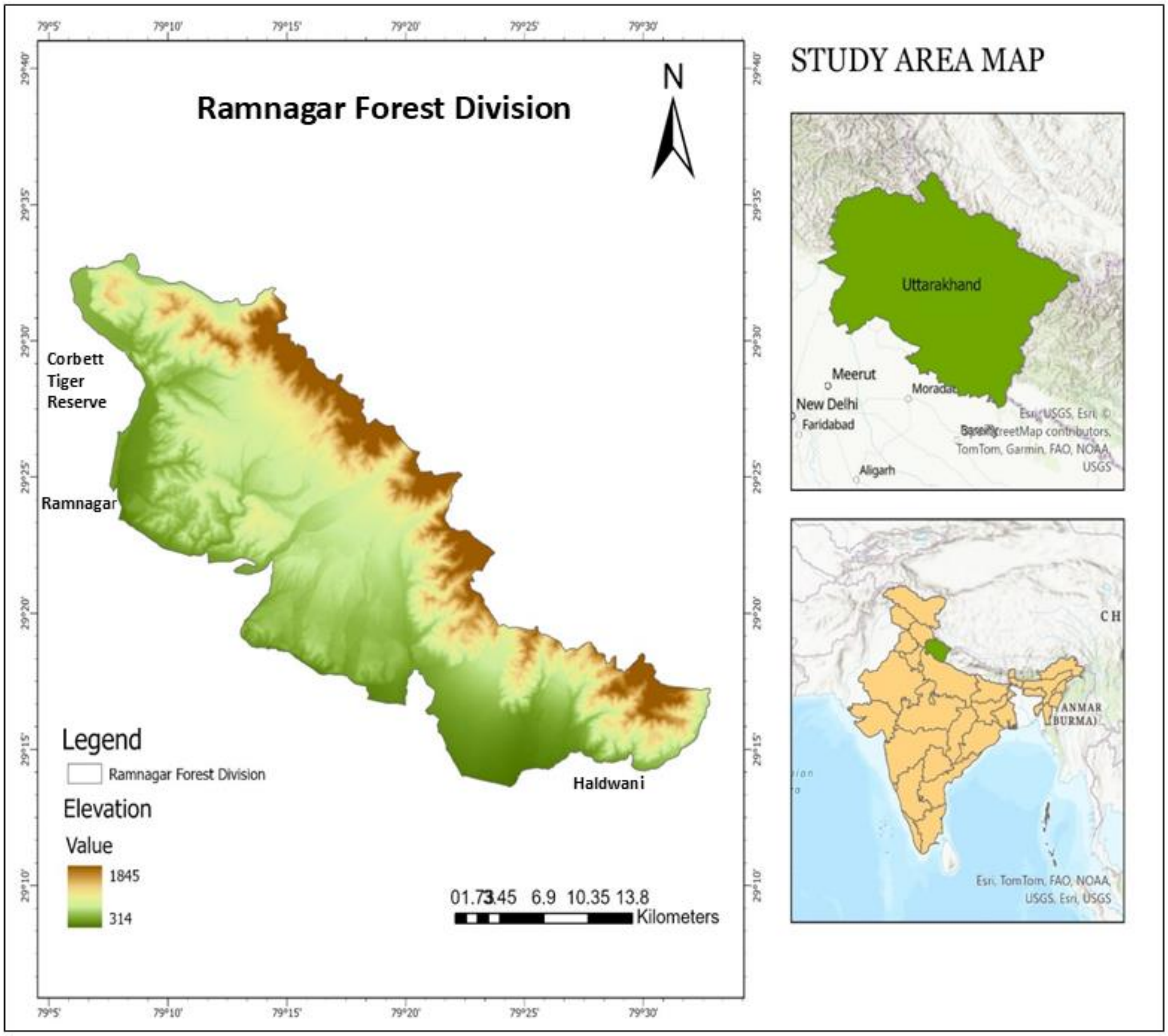


Fig 2.1 Map of Ramnagar Forest Division

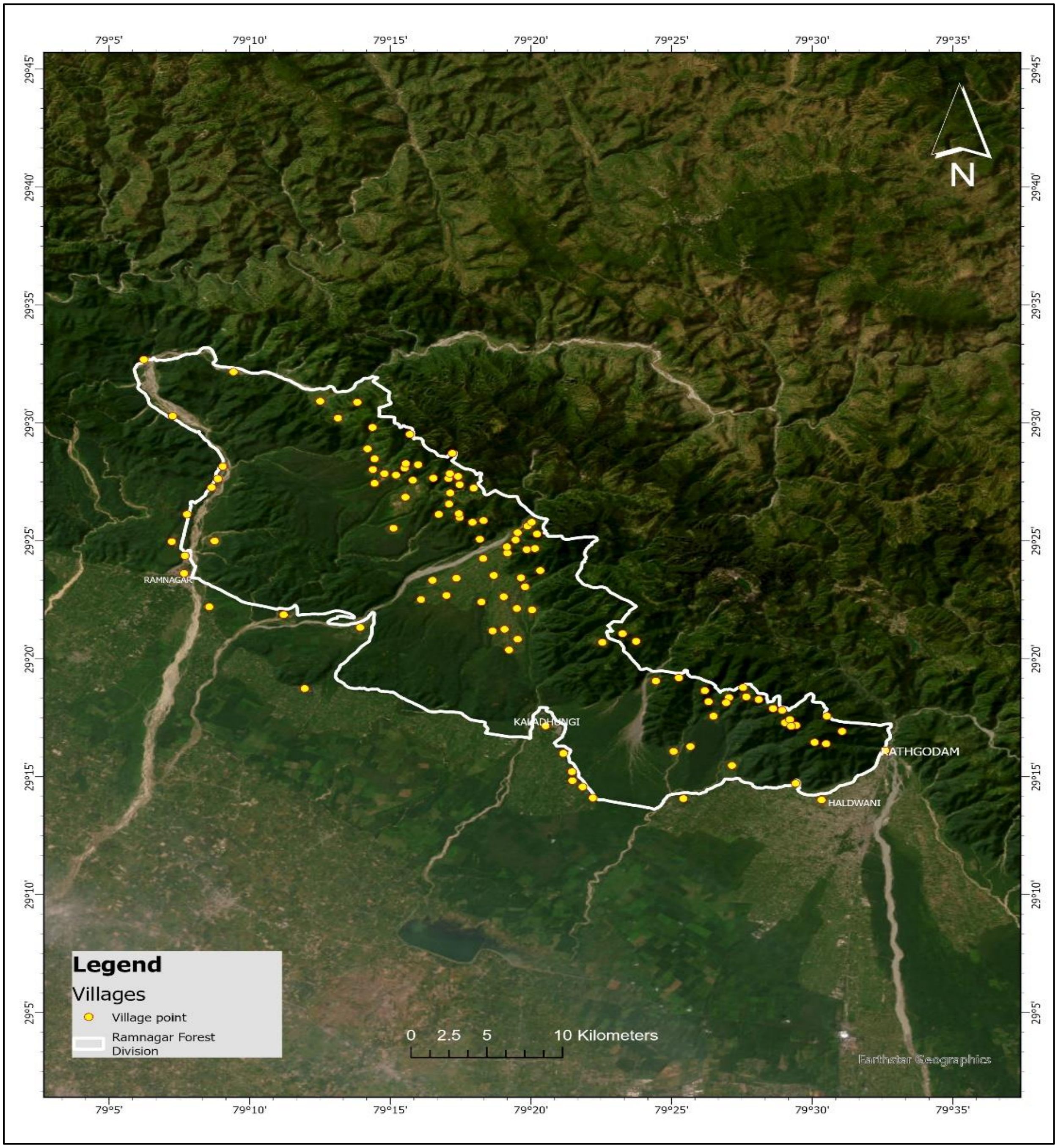


Fig 2.2 Map showing human settlements inside Ramnagar Forest Division

<u>Human habitations & their dependence on forest</u>

Along Kosi River

Because of habitable area and lack of clear government policy in dealing with the occu- pants, communities near the forest fringes have slowly, but steadily, encroached upon the forest area along the boundaries of this forest division. Ringora, Amdanda, and Tedha villages originated as cattle camps and together now have more than 80 households. Similarly, Sunderkhal, an encroachment since 1974, is now a 3.5 km long habitation, along the right bank of the Kosi River. The people in these villages depend on the adjacent areas of the Ramnagar Forest Divisiion for fuelwood, fodder, and small timber (Mazoomdar 2012). This dependency is causing considerable damage to the productive land system and is a serious impediment for animals moving from the Corbett TR to the Kosi River for water.

Kotabagh

Villages like Nathujala, Awala khot, Sonajala along the Dabka river report regular incidents of Human-Wildlife conflict. Several van panchayats like Syaat van panchayat one of the largest van panchayats together form most of the forest around the villages in this area. Dabka and Bor river passes through this area, although perennial a large part of their water is diverted for agriculture in this area through a network of small irrigation canals.

Kaladhungi

This area shares its boundaries with forest of Kaladhungi range, mostly dominated by orchards mango orchards this area faces a lot of damage to agriculture crops as well as to orchards from elephants. Bor river flows on its west side and Nihal om its east. Lots of mining operations are carried out in the Nihal River annually for a fixed time frame.

Fatehpur

This area along with Haldwani and Kathgodam shares a very sharp boundary with forest of Fatehpur Range. Tigers were believed to be absent in this area earlier but in the recent past there has been an increase in tiger numbers in this area and with this increase comes an increase in cases of livestock depredation and attacks on humans which at times had been fatal. This area is relatively drier than the rest of the division and faces frequent forest fires specially during the fire season. Gola on its east connects this continuous patch of forest to the Haldwani division.

<u>Connectivity</u>

Ramnagar Forest Division is connected to the Corbett Tiger Reserve mainly through three corridors namely Malani-Kota corridor near Ringora village, Chilkiya – Kota corridor near Sunderkhal village and South Patlidun – Chilkiya Corridor near Mohan industrial area. All these corridors are of high ecological priority and are been used regularly by elephants, tigers, and other wild animals.

Similarly, Fatehpur – Gadgadia corridor connects Ramnagar Forest Division to Terai Central Forest Division and is extensively used by elephants, tiger and leopards.

From Ramnagar Forest Division, forest connectivity is continuous until the township of Haldwani. Forest connectivity from Haldwani division to the Shuklaphanta National Park of Nepal is maintained by the Gola corridor forests along with Nandhaur Wildlife Sanctuary and Champawat forest division.

Status of Tigers

Last Population estimation exercise for Tigers (Jhala, 2023) revealed an astonishing 67 adult tigers which showed a considerable increase in tiger numbers from the last estimate of 39 individuals in 2015 (Department Records).

2.2 Field Methods

2.2.1 Objective 1: Line Transects

Sampling Design

A total of 69 line transects, each 2 kilometers in length, were established across the study area following a systematic random sampling design (Buckland et al., 2010). To enhance detection reliability and account for temporal variation in animal activity, each transect was surveyed three times. To minimize the risk of wildlife habituation to observer presence, temporal rotation was employed: transects initially surveyed at dawn were subsequently resampled at dusk, with a minimum interval of 36 hours between consecutive surveys on the same transect.

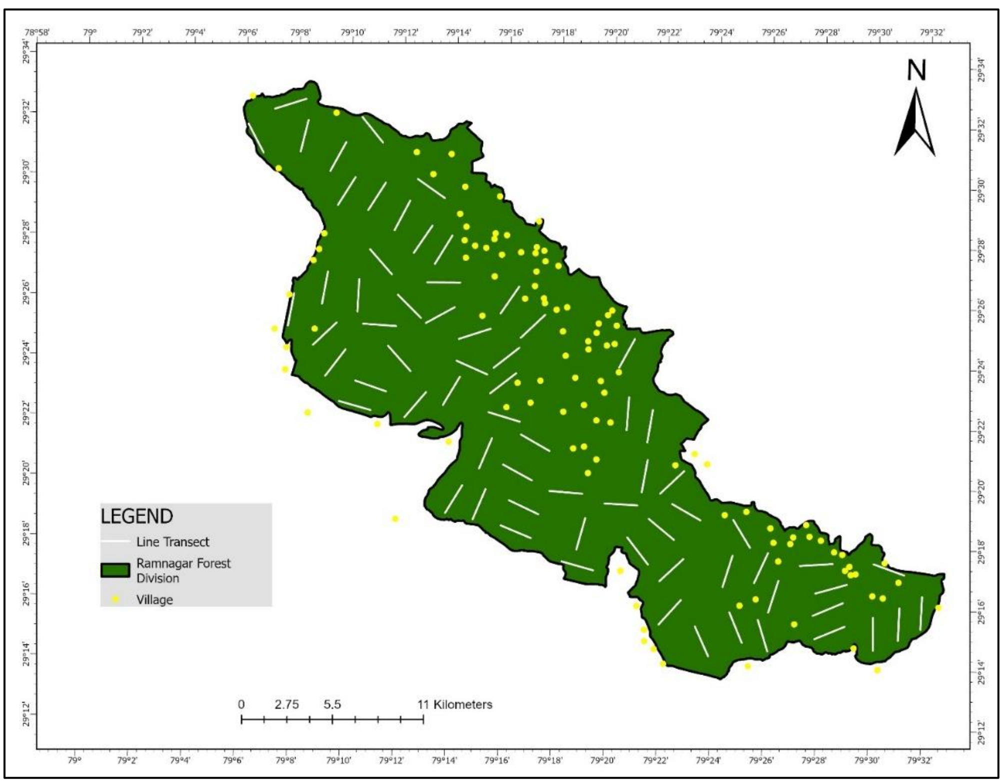


Fig.2.3 Study area map showing placement of transects.

2.2.2 Objective 2: Scat Sample Collection

Sample Collection

Animal trails were traversed regularly throughout the study area, tiger scat samples were identified based on field signs (tracks, scrapes), size, appearance, and the degree of coiling and constriction. Samples were collected in a paper bag along with GPS coordinates, date, habitat notes and signs. Samples were stored in cool, dry conditions using silica gel and transported to the laboratory for further analysis.

Prey identification

The undigested parts (hair, broken bones, hoof etc.) were separated by sieving the dried samples through sterile 0.5 mm stainless steel mesh. Slides were prepared with the primary guard hairs to identify tiger prey species (Mukherjee et al. 1994) and were examined for cuticle and medulla structures (Mukherjee et al. 1994; Karanth and Sunquist 1995; Biswas and Sankar 2002; Avinandan et al. 2008; Bahuguna et al. 2010).

2.3 Analytical Methods

2.3.1 Objective 1: Density Surface Model

Effective species management and conservation require knowledge of species distribution and status, line-transect distance sampling data was used to generate robust estimates of total abundance and simultaneously model the distribution, abundance, and spatial correlation of the species as a density surface model (DSM) (Miller, 2013; Camp, 2023).

A 2-stage analysis to model the spatial distribution and counts of the major prey species was conducted. In the first stage, detection probability was estimated. Using the R (R Core Team 2021) package distance (Miller, 2019), hazard-rate key detection functions with and without adjustment terms or covariates was fitted to the data. In the second stage, spatial correlation of the counts of detections using a penalized spline-basis smoothing with a generalized additive model (Wood, 2017) was modelled using the dsm package in R.

Line transects were split into contiguous segments (j) of 250 m length. Segment length was decided to keep the segment small enough such that neither density of objects nor covariate values vary appreciably within a segment, making the segments approximately square is usually sufficient; 2w * 2w, where w is the truncation distance (Miller, 2013). The area of each segment enters the model as (or as part of) an offset: the area of segment j is

$$A_j = 2wl_j$$

Count or estimated abundance (per segment or point) was then modelled as a sum of smooth functions of covariates using a generalized additive model. Smooth functions are modelled as splines, providing flexible unidimensional (and higher-dimensional) curves (and surfaces, etc.) that describe the relationship between the covariates and response.

Model used for the count per segment is:

$$\mathbb{E}(n_j) = \hat{p}_j A_j \exp\left[\beta_0 + \sum_k f_k\left(z_{jk}\right)\right]$$

z_{jk} denoting smooth functions with k indexing the covariates.

$(\hat{p}_j)$ denoting probability of detection.

PREDICTION

To predict abundance over the entire study area, a series of 250 m*250 m prediction cells were created over the study area. For each cell, the covariates included in the DSM were used; along with the area of each cell. After making predictions for each cell, an abundance map was plotted and, by summing over cells, an overall estimate of abundance was calculated.

2.3.2 Objective 2: Scat Analysis

Species Id

Morphological similarities between leopard and tiger scat makes field-based identification unreliable. Relying just on the field-based identification can lead to inaccurate assessments of diet composition, prey preferences, and ecological interactions. This makes it essential to accurately ascertain the species before conducting analyses to avoid such issues.

Genetic Species Identification

Mucosal layer on scat samples contains epithelial cells due to abrasions against the intestinal wall, this mucosal layer can be used to extract DNA. In order extract DNA outer layer from dry scat samples was scrapped and collected.

DNA extractions from all the collected 108 scats samples were performed using commercial stool DNA isolation kit (QIAamp DNA Stool Kit, QIAGEN Germany) as per protocol with minor modifications using about 200 mg of scrapped samples. Sequence-based methods to identify species from unknown scat samples (n =108) by amplifying mitochondrial DNA with primers described by Reeta et al. (2009).

Prey Identification

Relative frequencies of occurrences (RFO) (Mukherjee et al. 1994), prey biomass (Andheria et al. 2007) and prey preference (Sankar et al. 2010) were calculated. For RFO calculation, formula k/a*100 was used, where ‘k’ represents the frequency of number of samples in which a specific prey occurs and ‘a’ represents the total frequency count of all prey species (Kruuk 1989; Mukherjee et al. 1994).

To overcome the issue of overestimation of small prey species in RFO analysis (Andheria et al. 2007; Chakrabarti et al. 2016) using Ackerman’s equation: Y=1.980 + 0.035X, where Y=weight of consumed prey in each faeces and X=mean body weight of a particular prey species (Ackerman, 1984; Karanth and Sunquist 1995). The mean body weight of prey was taken from Upadhyaya et al. (2018). The relative biomass of the prey (D) was calculated following Karanth and Sunquist (1995); Andheria et al. (2007) formula D= (A*Y)/∑(A*Y)*100 where, A represents the RFO of each prey species.

Tiger prey preference for different species was calculated using Vanderploeg and Scavia’s relativized electivity index (Vanderploeg, 1979):

For each prey type i:

$$w_i = \frac{r_i/p_i}{\sum_{j=1}^{n}(r_j/p_j)}$$

wi represents normalized selectivity for prey i, ri represents of prey i in diet, pi represents proportion of prey i in environment and n for number of prey types.

Relativized index E*:

$$E_i^* = \frac{w_i - (1/n)}{w_i + (1/n)}$$

2.3.3 Objective 3: Mapping Conflict Hotspots

Conflict data available with the forest department was used to map conflict hotspots in the study area.

To determine the hotspot of conflict, 2x2 Km grid over the study area was overlaid and conflict incidents in each grid were calculated. GPS locations of each of the incident were not available. Inverse Distance Weighted Interpolation (IDW) technique in Spatial Analyst tool of ArcGis Pro 3.1 was used to determine the hotspots of conflict.

3.1 Density Surface Modelling

Hazard rate with no adjustments was the best fitting model for both chital and sambar.

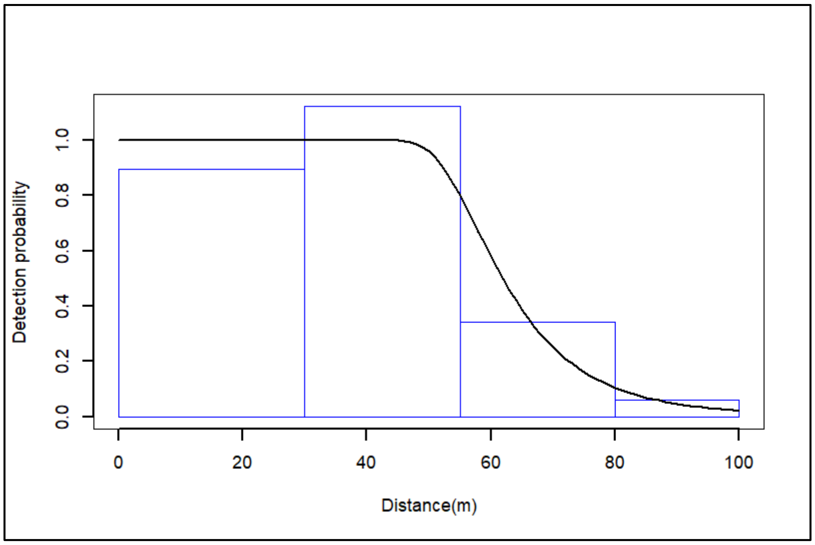


Fig. 3.1 Detection function plot for the model selected to estimate the chital detection probability.

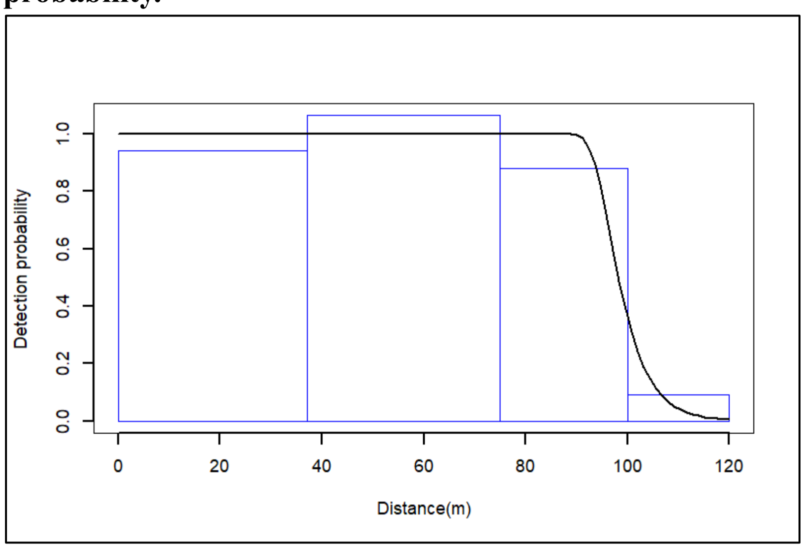


Fig.3.2 Detection function plot for the model selected to estimate sambar detection probability.

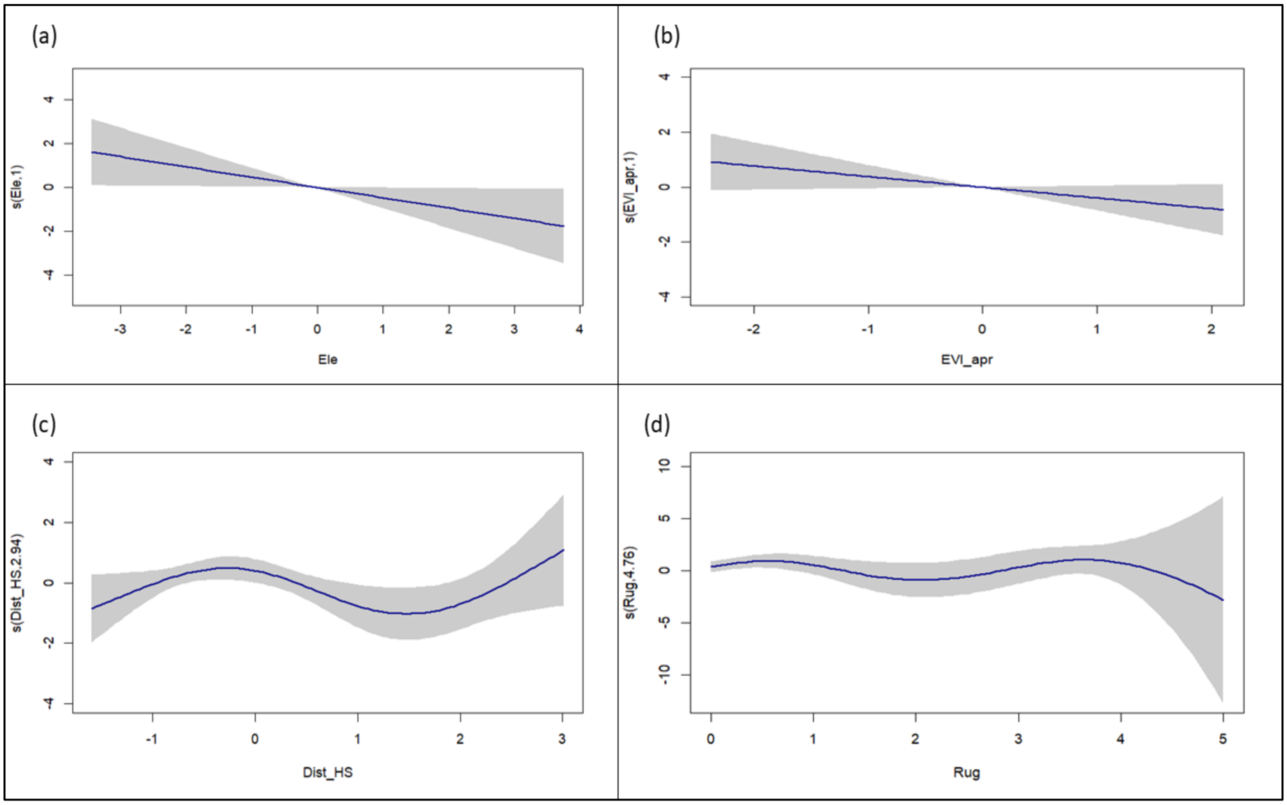


Fig.3.3 Partial effect plots (smooth terms) from Generalized Additive Models (GAMs) showing the influence of environmental variables on the predicted density of chital (a, b) and sambar (c, d). The y-axes represent the estimated smooth function for each variable, with shaded areas indicating 95% confidence intervals. (a) Effect of elevation (Ele) on chital density (b) Effect of Enhanced Vegetation Index (EVI_apr) on chital density (c) Effect of distance to human settlements (Dist_HS) on sambar density (d) Effect of terrain ruggedness (Rug) on sambar density.

Species	Estimated number	Standard error	CV	Population density (Individuals/Sq. Km)	Model	Family	Link Function
Chital	2053	595	29%	3.16	Hazard-rate key function	Negative Binomial	log
Sambar	939	158	~17%	1.44	Hazard-rate key function	Quasipoisson	log

Table.3.1 Estimated population sizes and model details for chital and sambar based on density surface modeling.

Density surface model-based population estimate for Chital was highest (2053 ± 595) followed by Sambar (939 ± 158) (Table 3). Distribution of Chital was affected by Elevation and EVI (Fig. 3.3a, b). Chital showed steady decrease of count with increase in elevation and EVI. Sambar distribution was affected by distance from human settlement and ruggedness (Fig. 3.3, d). While moderate increase in ruggedness does not affect sambar density but in highly rugged terrain it shows a sharp decline in sambar densities, curve for how sambar densities vary with distance to human settlements shows a peak at distances slightly below and above 0 (close to human settlement) and at distances farther away, suggesting that sambar may be drawn to resources near human settlements but also prefer areas with less disturbance at greater distances.

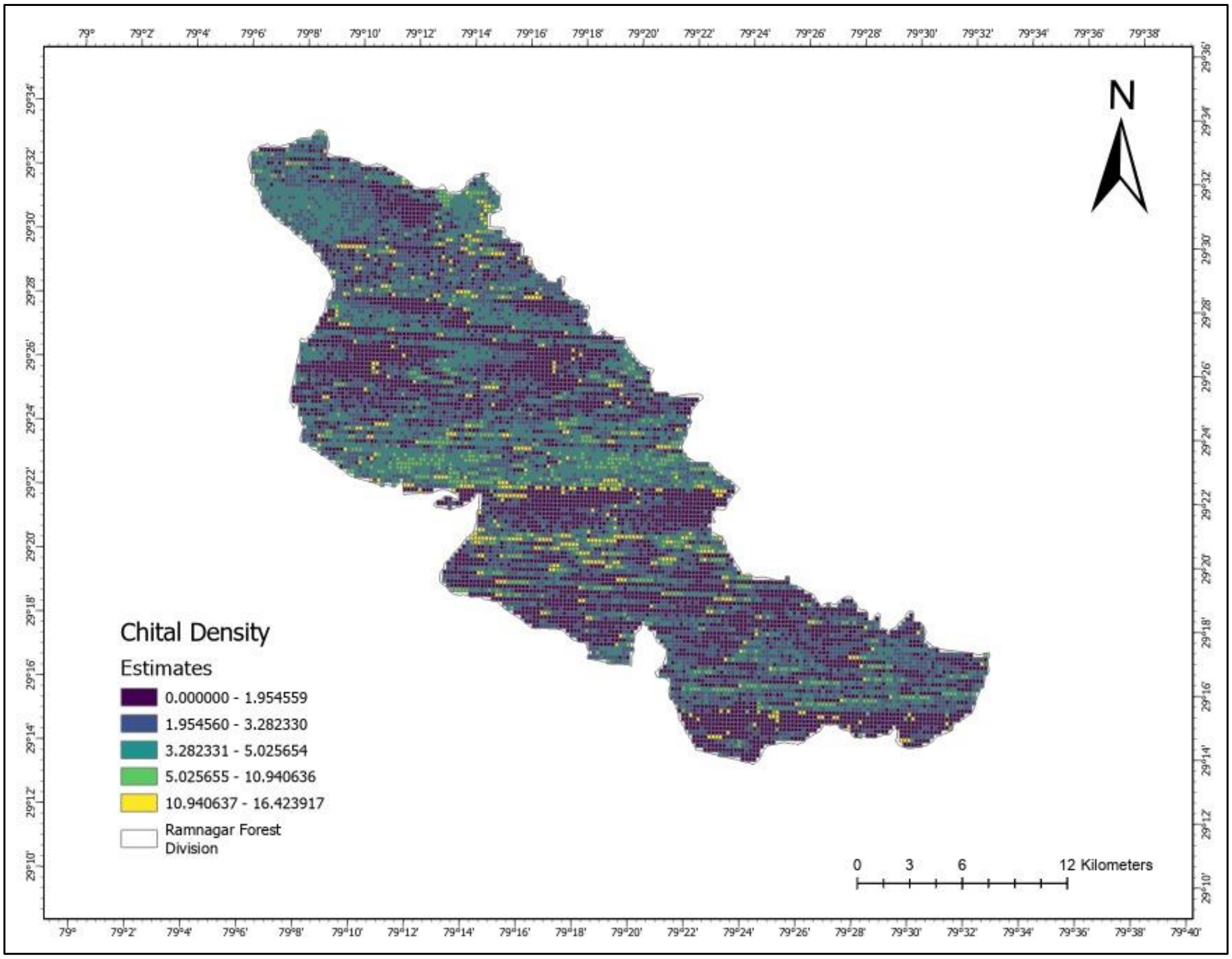


Fig.3.4 Chital Density Surface Map for Ramnagar Forest Division.

Chital density surface map shows small but almost uniformly distributed areas of sporadically high chital densities. These areas as the partial effect plots suggest, probably are open habitats at low elevations.

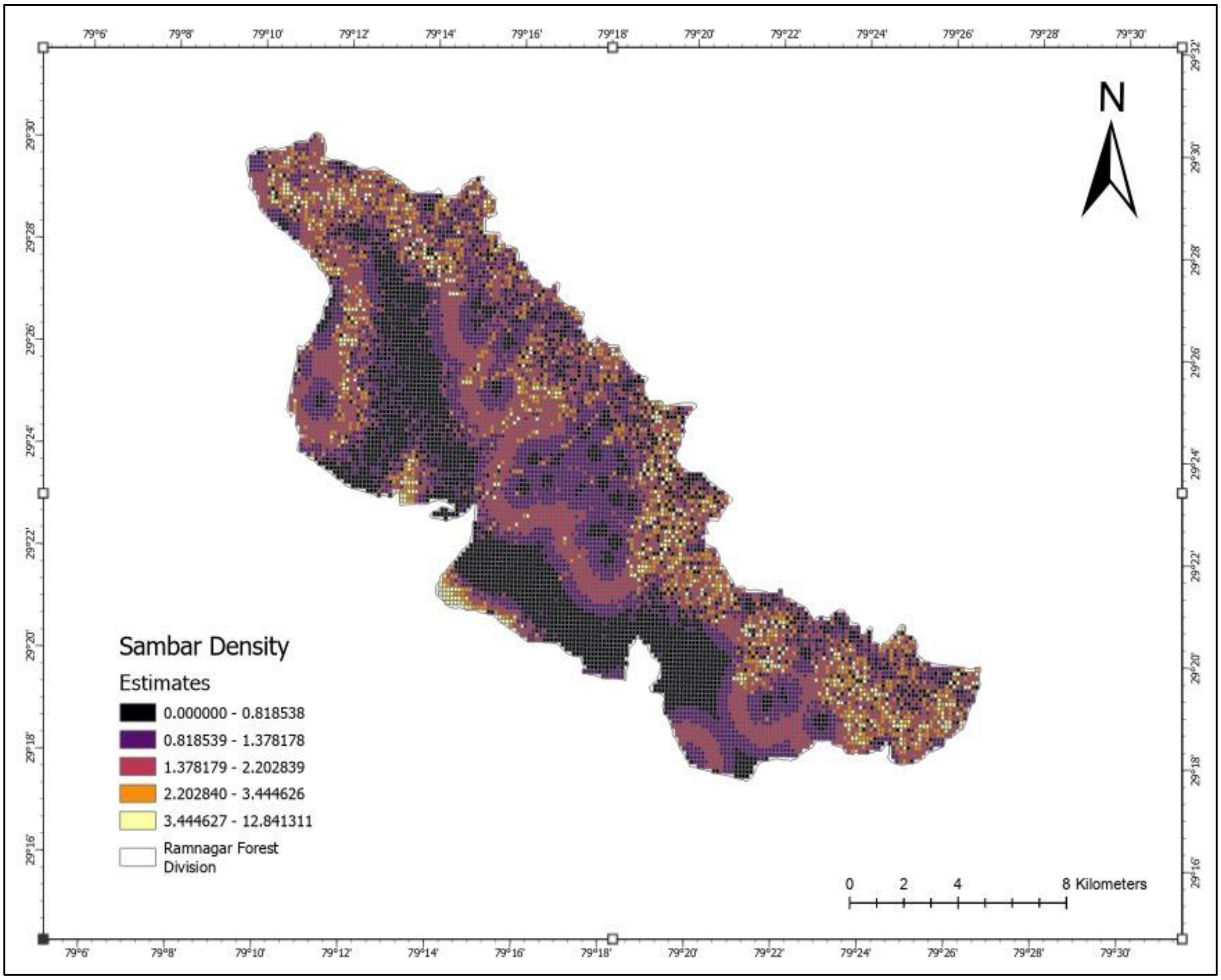


Fig.3.5 Sambar Density Surface Map for Ramnagar Forest Division.

Sambar density surface map shows a clear pattern of moderately high densities of sambar near almost all areas close to human settlements and sporadically high densities in some of the areas near human settlements as well as areas deep inside the forest where human disturbance is relatively low.

3.2 **Diet Analysis**

A total of 72 genetically confirmed tiger fecal samples from Ramnagar Forest Division were used. Out of these tiger faeces, 67 samples (success rate ~ 93%) produced data on the prey species assemblage. The remaining samples (n = 5, ~7%) contained damaged hairs and were discarded from analyses.

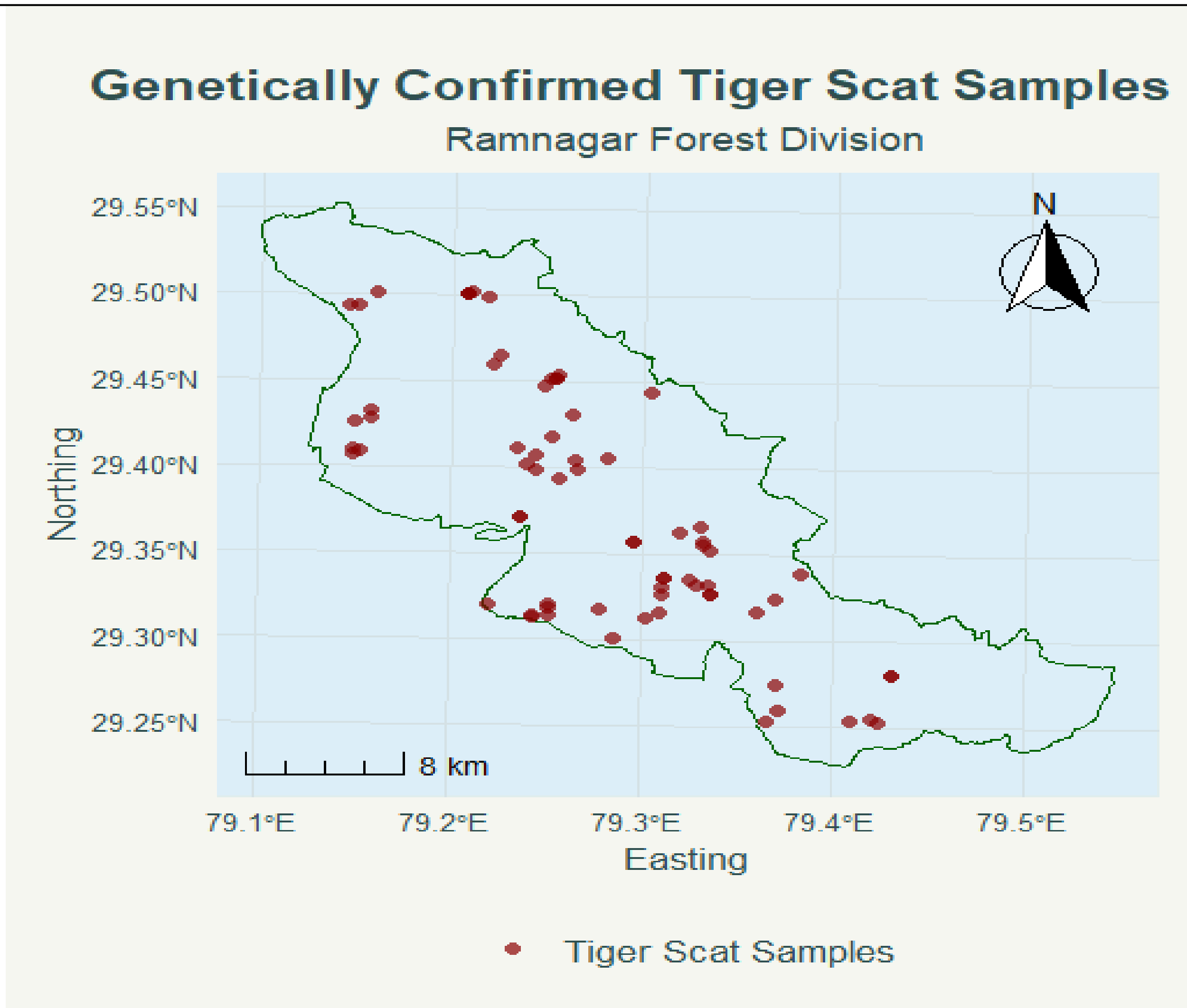


Fig.3.6 Map showing genetically confirmed tiger scat samples locations.

Prey Species	Relative Frequency of Occurrence (%)	Utilization of Prey Species (r)	Mean body weight of prey (in Kg)	Weight of Consumed Prey	Relative Biomass (%)
Chital	32.39	34.65	50	3.73	15.7
Sambar	26.76	29.23	185	8.455	30
Livestock	12.68	12.68	275	11.605	17.9
Wild Pig	16.90	14.07	35	3.205	5.48
Primates	2.82	2.27	10	2.33	0.643
Barking Deer	4.23	2.41	25	2.855	0.837
Nilgai	2.82	3.08	181	8.315	3.11
Rodent	1.41	0.44	0.2	1.987	0.106

Table.3.2 Details of various Tiger prey parameters for all 8 prey species identified within Ramnagar Forest Division.

Tiger consumed mainly chital, sambar, livestock, wild pig, barking deer, nilgai, primates and rodents. Large-bodied (wild and domestic) prey species comprised 91.55% (RFO) of tiger diet whereas small-bodied prey species contributed only 8.46% (RFO) of the tiger diet.

Prey Species	Utilization of prey species (r)	Abundance of prey species (p) (Relative abundance) *	Normalized selectivity for prey (*w*)	Vanderploeg and Scavia's relativized electivity index (E*)
Chital	34.65	68.7	0.3507	-0.18
Sambar	29.23	31.3	0.6493	0.13

Table.3.3 Chital and Sambar electivity index details. (*Abundance data from density surface modelling used)

E* value of -0.18 for chital indicates that tigers show slight avoidance to chital while E* values of 0.13 indicate slight preference for sambar. Sambar is less abundant than chital (Table 3.1), but they contribute ~27% of tiger's diet. This data shows that tigers are not simply eating prey in proportion to what is available. Although, it clearly shows slight preference for sambar over chital, but still this data indicate relative selection between these two species, not absolute preference across all possible prey.

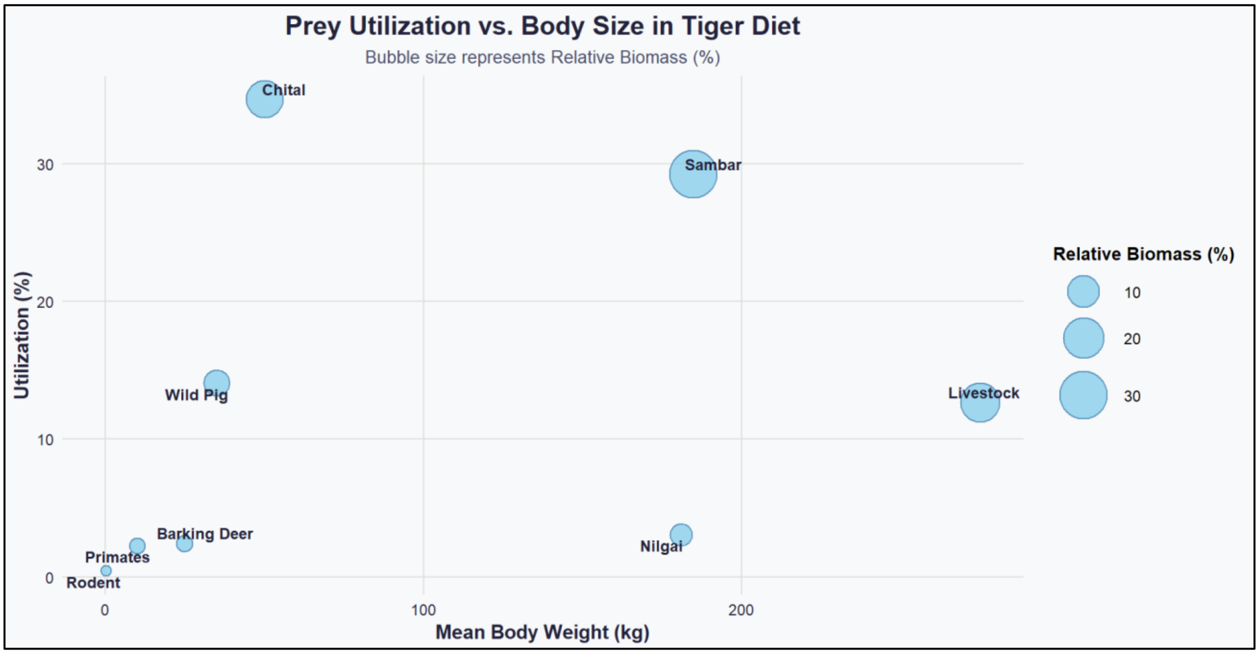


Fig.3.7 Prey Utilization vs Body Size in Tiger Diet.

3.3 <u>Human-Tiger Conflict</u>

353 incidents of livestock depredation by tiger were reported between 2017 and 2023. Overall, the data showed an increasing trend with the highest number of incidents being reported in 2020 (n=100) and almost 50 incidents reported at an average each year.

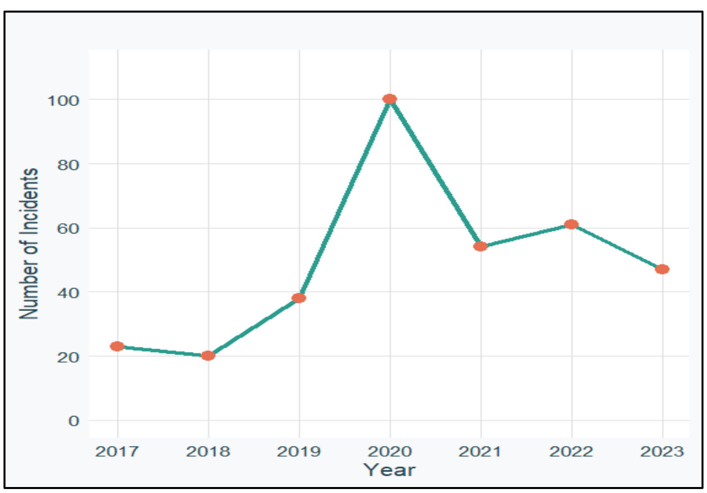


Fig.3.8 Number of reported livestock depredation incidents each year.

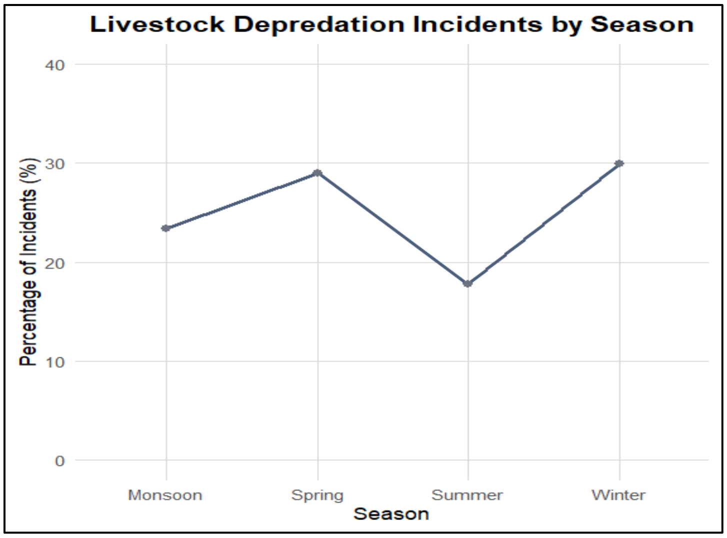


Fig.3.9 Graph showing seasonal differences in the number of livestock depredation events.

Seasonal differences in the number of livestock depredation incidents were checked using Chi square analysis to check statistical significance. Results show no statistically significant differences (X-squared = 4.0654, df = 3, p-value = 0.2545, $p>0.05$). This shows no seasonal change in the number of livestock depredation incidents.

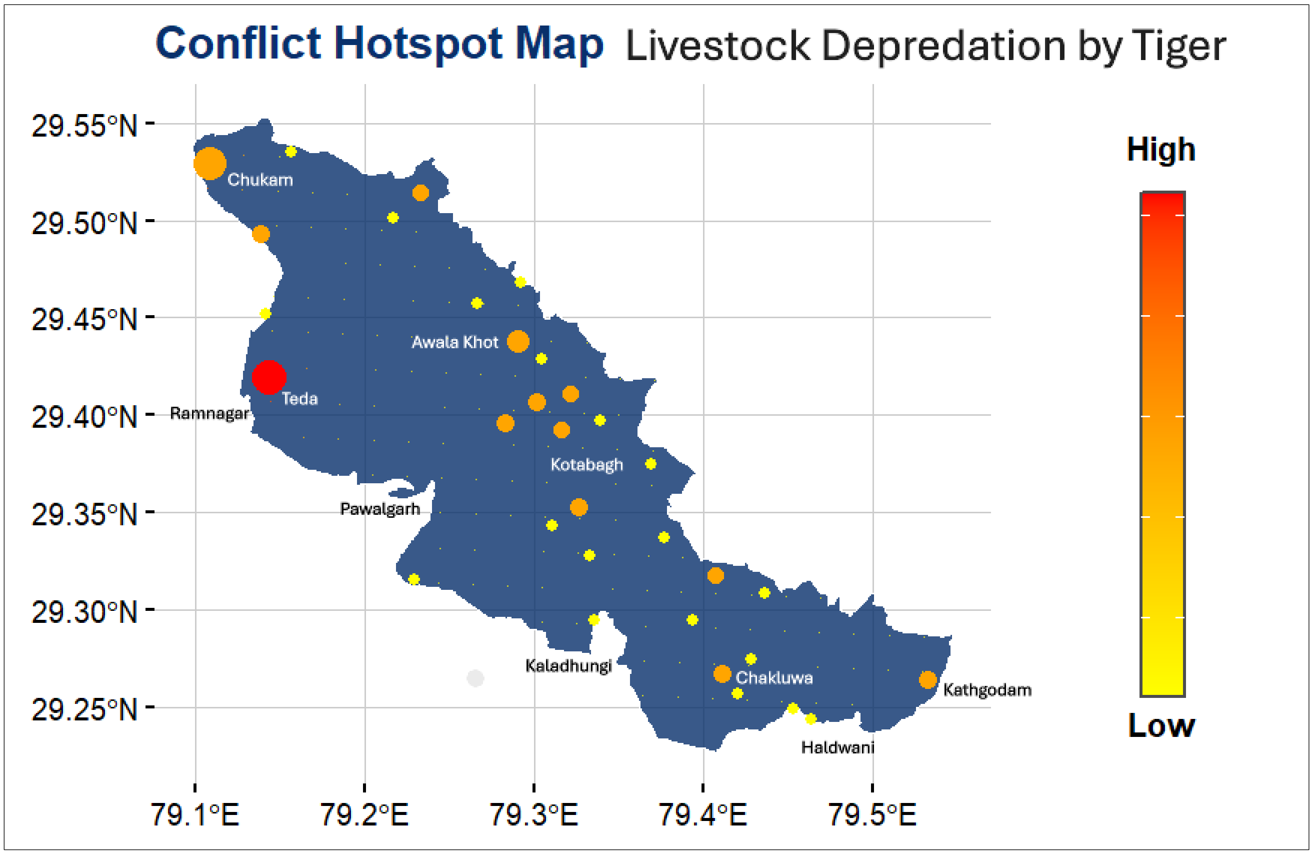


Fig.3.10 Conflict hotspot map showing hotspots of livestock depredation by Tiger.

Hotspot analysis showed Teda, Chukam, Awala Khot, Mayarampur, Devgaon, Nathujala, Dhapla and Chakluwa to be the major conflict hotspots with the highest number of livestock depredation incidents being reported from Teda.

Analysis of recorded incidents shows that 81% of livestock depredation occurred within village boundaries. Of these, 43% of livestock were taken from cowsheds, 27% from agricultural fields within villages, and 11% from the village boundaries. Only 19% of incidents occurred inside the reserve forest area.

A chi-square goodness-of-fit test was conducted to determine whether this distribution differed significantly from what would be expected if depredation occurred equally across all locations. The test yielded a highly significant result ($\chi^2 = 38.28$, df = 3, $p < 0.000001$), indicating that livestock depredation is not evenly distributed but is instead concentrated within village areas, particularly in cowsheds and agriculture fields.

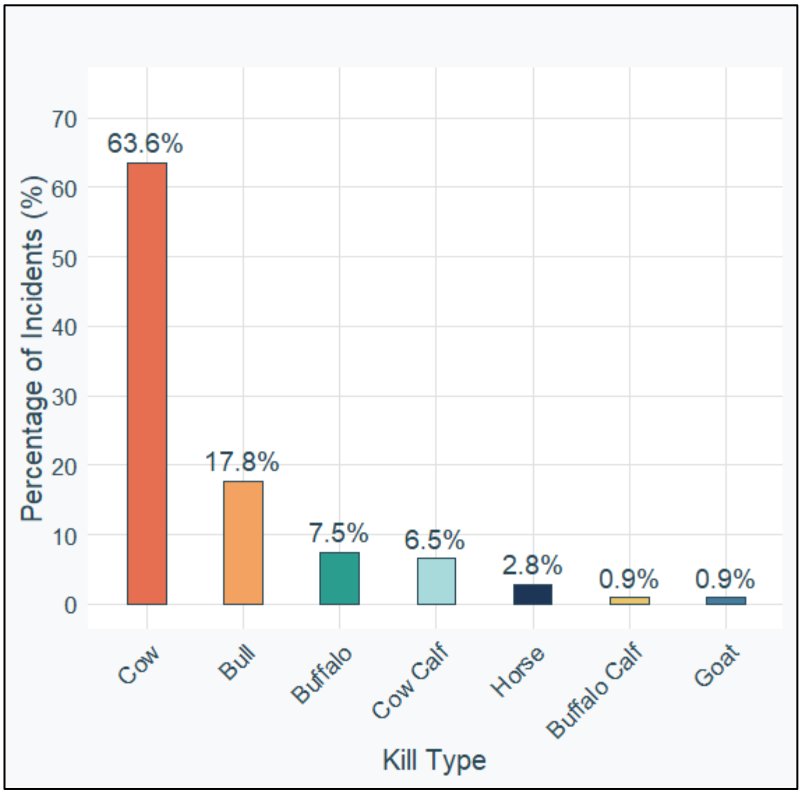


Fig.3.11 Graph depicting the percentage of each kill type.

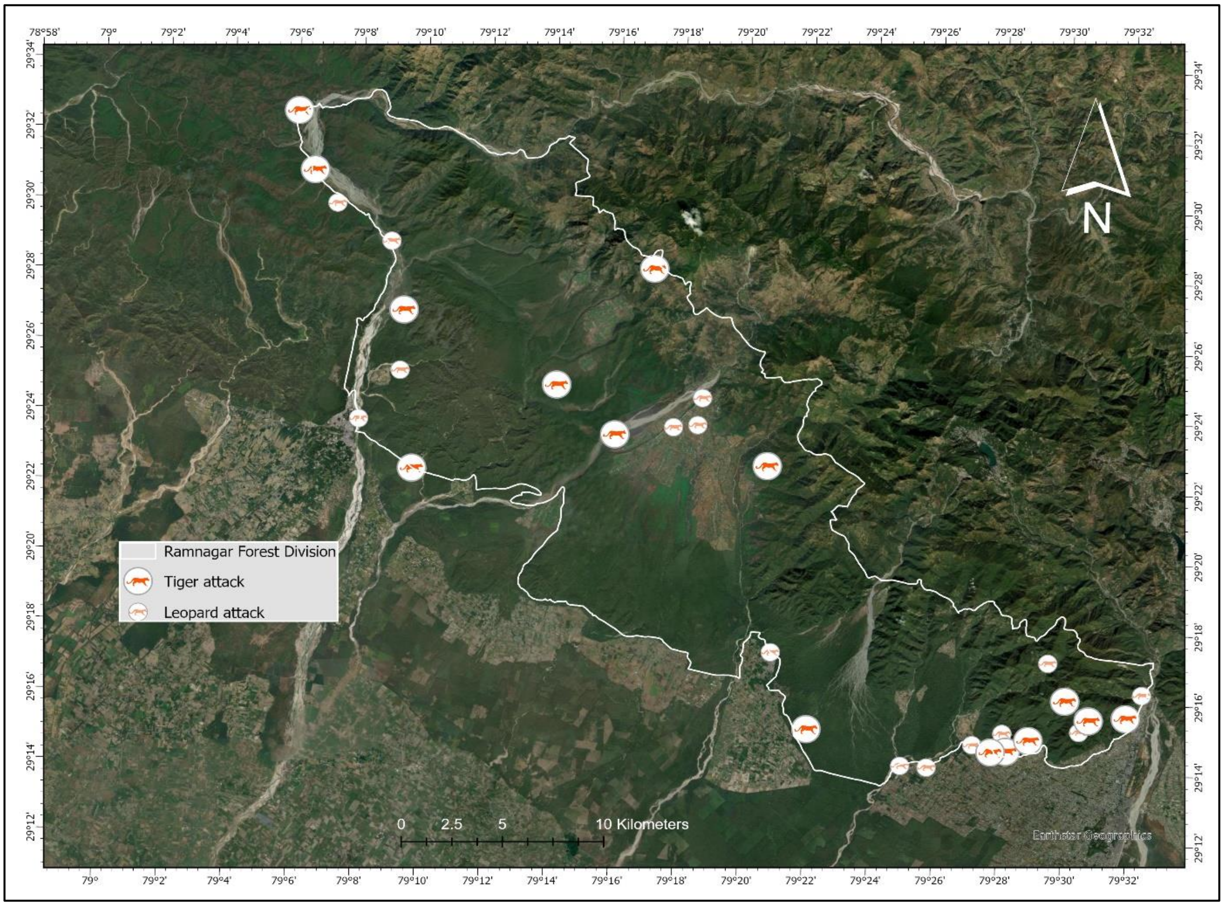
Cow (63.6%) was the most killed livestock out of all the 7 livestock animals killed by tigers, followed by bull (17.8%), buffalo (7.5%), cow calf (6.5%), horse (2.8%), buffalo calf (0.9%) and goat (0.9%).

Cow was the most abundant livestock in the area (20th Livestock Census, 2019), data shows multiple individuals being killed at a time. Stray cattle's, were common all around the study area boundary, therefore not all livestock depredation events were reported.

Tiger Attacks on humans

Over a period of 13 years from 2013 to 2025 48 attacks on humans were reported in total out of which 28 incidents were attributed to tigers and 20 attacks were attributed to leopards.

Fig.3.12 Map showing sites of tiger and leopard attacks on humans.



Data on attacks on humans shows no clear pattern indicating that chance encounters near settlements is the major reason behind these incidents. Only Fatehpur (Southeastern part of the study area) reported incidents of habitual man-eating in 2022.

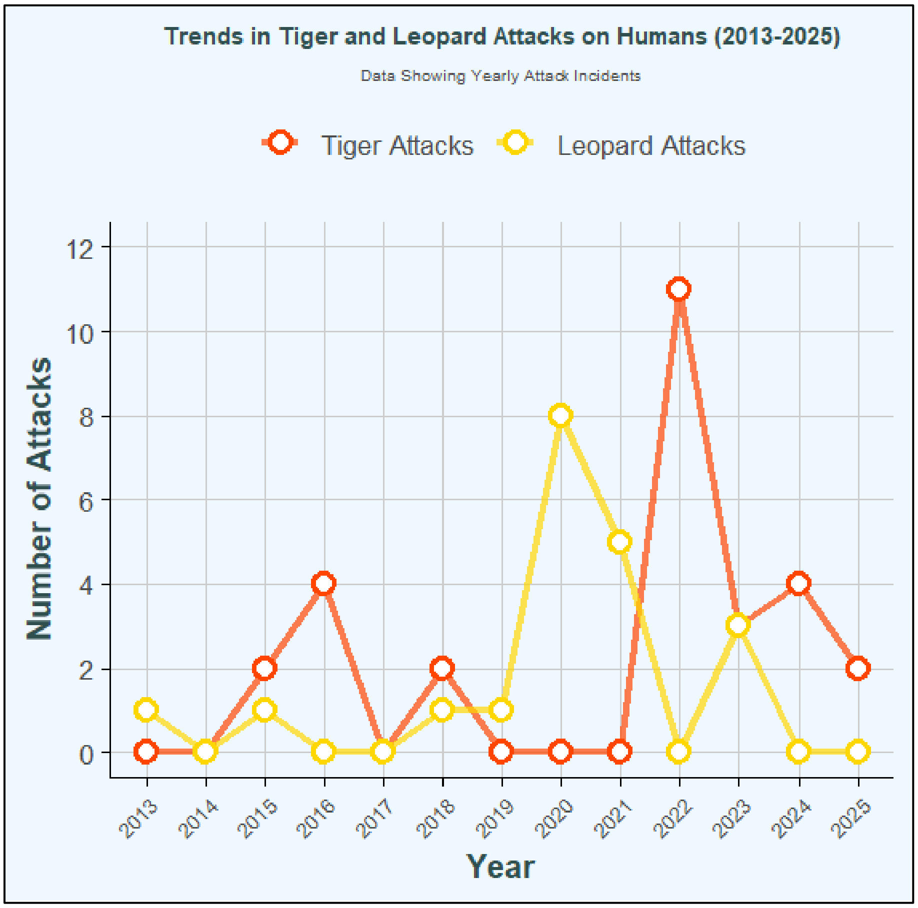


Fig. 3.13 Yearly trend in Tiger and Leopard attacks on humans (2013-2025).

Tiger attacks peaked in 2022(n=11 attacks), with several incidents reported in 2015 (n=2), 2016 (n=4), 2018 (n=2), 2023 (n=3) 2024 (n=4), and 2025 (n=2). Similarly, leopard attacks peaked in 2020 (n=8) and 2021 (n=5), with several incidents reported in 2013, 2015, 2018, 2019 and 2023. Poisson Regression test was conducted to detect trends in the data. Results ($p = 0.0286 < 0.05$, coefficient = 0.138) shows a significant increasing trend in tiger attacks over the years.

Chapter 4 - Discussion

As our vision of tiger conservation with growing tiger numbers is shifting from land sparing which is more of an exclusive approach to both land sharing and land sparing which is an inclusive approach to an extent, it becomes extremely essential to focus on the tiger's living outside protected areas in shared spaces where they often interact with humans in direct and indirect ways. Ramnagar Forest Division in the Western Terai Arc Landscape forms an extension of the Corbett Tiger Reserve, connecting this landscape with the Central Terai Arc Landscape and Nepal part of Terai Arc Landscape through Haldwani Forest Division and Terai East Forest Division. Forest divisions are often managed to maximize timber production and animals often face high level of disturbance due to logging and mining operations. But, Ramnagar Forest Division has seen a rapid increase in tiger numbers from 39 adults in 2015 (Department Records) to 67 adults in 2022 (Jhala, 2023), supporting the highest densities of wild tigers outside any protected area.

4.1 Density Surface Modelling

Density surface modelling in Ramnagar Forest Division revealed low population estimates for chital (2053 ± 595) and sambar (939 ± 158), aligning with literature indicating that habitat alterations impact ungulate densities (Karanth, 2004; Harihar, 2014). Chital density exhibited a linear decline with increasing elevation and Enhanced Vegetation Index (EVI), consistent with their preference for open habitats like grasslands at lower elevations (Schaller, 1967; Berwick, 1974). High EVI values, indicative of dense vegetation and canopy cover, correlate with reduced chital presence, as these generalist foragers thrive in forest edges and ecotone zones (Eisenberg, cited in Schaller, 1967). The conversion of grasslands to teak plantations in the early 1990s, as documented in departmental records, significantly reduced open habitats, explaining the low chital density observed. This habitat modification mirrors findings from other multi-use forests where silvicultural practices, such as Assisted Natural Regeneration (ANR), diminish suitable habitats for grazing ungulates (Rangarajan, 1996).

Sambar density showed a non-linear relationship with distance to human settlements and terrain ruggedness, supporting studies that highlight sambar's adaptability to varied landscapes (Shankar, 1994; Kumar, 2020). Sambar density remained stable in low to moderate rugged terrain but dropped sharply in highly rugged areas, consistent with their preference for less challenging topography (Shankar, 1994). The bimodal distribution of sambar density—peaking near human settlements and in less disturbed areas farther away—suggests resource attraction near villages, possibly due to crop raiding and waste dump foraging (Kumar, 2017; Nagarale, 2024). This pattern aligns with literature noting sambar's opportunistic feeding in human-modified landscapes (Lamichhane, 2022). The high sambar density near forest fringes underscores their reliance on human-provisioned resources, a trend observed in multi-use forests with low wild prey availability (Harihar, 2014).

Field Observation: Plastic Entering the Food Chain

Field observations revealed plastic in the gut of a tiger-killed sambar and in tiger scat, highlighting the pervasive impact of plastic pollution in multi-use forests. This finding corroborates studies showing that ungulates like sambar, foraging in waste dumps near human settlements, ingest plastics, which are then transferred to predators like tigers (Nagarale, 2024). Such ingestion poses risks of gastrointestinal blockages, toxicity, and malnutrition, threatening both prey and predator health (Goodrich, 2010). This issue is exacerbated in areas with poor waste management, a common challenge in human-dominated landscapes adjacent to forests (Inskip & Zimmermann, 2009)

Fig.4.1 Tiger Kill with plastic in its gut

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Fig.4.2 Tiger Scat sample with plastic.

4.2 Diet Analysis

Diet analysis of 67 genetically confirmed tiger scat samples revealed that large-bodied prey dominates tiger diets (91.55% RFO), with sambar contributing the highest relative biomass (30%), followed by livestock (17.9%) and chital (15.7%). This aligns with literature indicating tigers preferentially select large-bodied ungulates like sambar for their high energetic return (Karanth & Sunquist, 1995; Hayward, 2012; Lamichhane, 2022). The high predation on chital, despite their lower biomass contribution, reflects their numerical abundance in the study area (Harihar, 2011). However, Vanderploeg and Scavia's relativized electivity index ($E^* = -0.18$ for chital, 0.13 for sambar) indicates a slight preference for sambar over chital, consistent with studies showing tigers target larger prey when available (Hayward, 2012; Allen, 2021). The significant contribution of livestock to tiger diet (17.9%) reflects the low density of wild prey, a pattern observed in multi-use forests with high human activity and depleted wild ungulate populations (Biswas, 2023; Bagchi, 2003). This reliance on livestock underscores the ecological stress in Ramnagar, where habitat degradation and competition with livestock reduce wild prey availability (Karanth, 2004).

4.3 Human-Tiger Conflict

Between 2017 and 2023, 353 livestock depredation incidents were reported, with a peak in 2020 (n=100) and an average of 50 incidents annually. Hotspots like Teda, Chukam, and Awala Khot highlight the spatial concentration of conflict near human settlements, where 81% of incidents occurred, particularly in cowsheds and agricultural fields ($\chi^2 = 38.28$, df = 3, $p < 0.000001$). This pattern aligns with literature noting that tigers venture into human-dominated areas when wild prey is scarce, targeting livestock as an easier food source (Karanth, 2004; Harihar, 2014). The high predation on cows (63.6%) reflects their abundance in the area, consistent with findings from multi-use forests (Lamichhane, 2023). The absence of significant seasonal variation in depredation

($\chi^2 = 4.0654$, df = 3, p = 0.2545) suggests consistent tiger reliance on livestock year-round, likely due to low wild prey density (Bagchi, 2003).

Tiger attacks on humans (28 incidents from 2013–2025, peaking in 2022 with 11 attacks) show a significant increasing trend (Poisson regression, p = 0.0286), driven by chance encounters near settlements and, in one case, habitual man-eating in Fatehpur. This aligns with studies indicating that human-tiger conflict escalates in areas with high human activity and fragmented habitats (Goodrich, 2010; Barlow, 2009). Retaliatory killings, a common response to livestock loss and human attacks, pose a severe threat to tiger populations, particularly in multi-use forests (Karanth & Sunquist, 1995).

4.4 Conservation Implications

The results from Ramnagar Forest Division reveal a complex interplay of ecological degradation, human-wildlife conflict, and environmental pollution that threatens the sustainability of its high tiger density outside protected areas. With low population estimates for chital (2053 ± 595) and sambar (939 ± 158), significant tiger reliance on livestock (17.9% of diet biomass), plastic contamination in the food chain, and escalating conflicts (353 livestock depredation incidents from 2017–2023 and 28 human attacks from 2013–2025), conservation strategies must address habitat loss, prey depletion, conflict, and pollution through integrated, community-focused approaches. Below, we elaborate on these implications based on the study’s findings.

1. Restoring Habitats to Boost Wild Prey Populations

The low chital density, driven by the conversion of grasslands to teak plantations in the early 1990s, highlights how past management decisions prioritizing timber production have diminished open habitats critical for chital, a species favoring grasslands and forest edges. Sambar’s reliance on crops and waste dumps near human settlements further indicates a shortage of natural forage within the forest. These patterns suggest that habitat degradation and competition with livestock have severely limited wild prey availability, forcing tigers to depend on livestock.

Conservation efforts should focus on restoring open habitats like grasslands and ecotone zones to support chital populations. This could involve controlled burns to maintain grass cover, selective clearing of teak plantations in low-elevation areas identified as high-density chital zones (Fig. 3.4), and halting practices like Assisted Natural Regeneration (ANR) in key ungulate habitats, as dense forest regeneration reduces grazing areas. For sambar, enhancing natural forage availability through rewilding efforts, such as planting palatable native grasses in less disturbed forest areas, could reduce their dependence on human-provisioned resources. Restoring prey populations would decrease tiger predation on livestock, stabilizing the ecosystem. Maintaining connectivity between forest patches is also essential to allow prey and tiger movement, supporting population resilience in fragmented landscapes.

2. Mitigating Human-Tiger Conflict

The high rate of livestock depredation (353 incidents from 2017–2023, with 81% within village boundaries) and increasing human attacks (peaking at 11 in 2022) reflect the intense pressure of human-wildlife overlap in Ramnagar. Conflict hotspots like Teda, Chukam, and Awala Khot, coupled with the high predation on cows (63.6%), indicate that tigers are drawn to human settlements by abundant livestock and sambar foraging near villages. The lack of seasonal variation in depredation suggests consistent tiger reliance on livestock due to low wild prey availability.

To mitigate conflict, predator-proof livestock enclosures should be prioritized in hotspot areas, particularly for cowsheds and agricultural fields where most incidents occur. Community vigilance programs, such as night patrols or early-warning systems using motion sensors, can deter tigers from entering villages. Compensation programs for livestock losses must be streamlined to ensure timely and fair payments, reducing the likelihood of retaliatory killings. Regulating livestock grazing by designating zones away from forest fringes can minimize competition with wild ungulates and reduce tiger-livestock encounters. Community workshops to promote better animal husbandry practices, such as securing livestock at night, can further lower depredation risks.

3. Tackling Plastic Pollution in the Food Chain

The discovery of plastic in sambar gut contents and tiger scat reveals a critical environmental threat. Sambar foraging in waste dumps near human settlements ingest polythene, which transfers to tigers, risking health issues like blockages, toxicity, and malnutrition. This pollution is exacerbated by poor waste management in villages bordering the forest, a common issue in human-dominated landscapes.

Conservation strategies must include robust waste management initiatives. Community-led programs for waste collection and recycling can prevent wildlife access to dumpsites. Installing covered bins and organizing regular waste pickups in villages near forest fringes are practical steps to reduce plastic availability. Public awareness campaigns can educate residents about the dangers of plastic pollution to wildlife, encouraging proper disposal and segregation. Partnerships with local authorities to enforce waste management regulations are essential to create a sustainable system, protecting both prey and predator health.

4. Adopting Socio-Ecological and Landscape-Level Strategies

Ramnagar's high tiger density, despite low wild prey, underscores their adaptability to human-dominated landscapes, but this comes at the cost of increased conflict and reliance on livestock. A landscape-level approach is needed to balance ecological and human needs. This includes maintaining ecological corridors to support tiger dispersal and prevent genetic isolation in fragmented habitats. Investing in rural development, such as promoting sustainable agriculture with crops less attractive to sambar or installing protective fencing, can reduce ungulate crop raiding and their reliance on human resources.

Community engagement is critical to foster coexistence. Educational programs highlighting the ecological role of tigers and their cultural significance can build local support for conservation. Providing alternative livelihoods, such as eco-tourism or handicraft initiatives, can reduce community dependence on forest resources, decreasing human-wildlife overlap. Participatory management, where locals are involved in monitoring and decision-making, can further enhance tolerance and reduce negative interactions.

5. Reforming Policy and Management Practices

Current forest management practices, rooted in timber-focused strategies like teak plantations and ANR, are incompatible with large carnivore conservation. Policies should shift toward biodiversity-centric approaches, integrating prey base enhancement and habitat restoration into forest management plans. Regular monitoring of prey populations using density surface modelling can inform adaptive management, ensuring timely interventions. Establishing rapid-response teams to handle conflict incidents and, if necessary, translocating problem tigers can prevent escalation of tensions. Spatial risk mapping, as shown in the conflict hotspot analysis (Fig. 3.10), should guide targeted mitigation efforts, optimizing resource allocation.

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Covariate	**Source**
VRM	**Calculated using Vector Ruggedness Measure tool in ArcGIS Pro 3.1.0.**
EVI (Enhanced Vegetation Index)	**Sentinnel 2 Dataset**
DEM	**SRTM Dataset**
Distance to human settlement	**Calculated with the help of Distance Accumulation tool in ArcGIS Pro 3.1.0.**
Distance to water	**Calculated with the help of Distance Accumulation tool in ArcGIS Pro 3.1.0.**

A pangolin captured on one of our trail cameras during fieldwork.

Sandni Chaur, Grassland mostly dominated by *Imperata cylindrica* grass Which is palatable primarily when young and frequently cut, but its mature leaves become sharp, tough, and irritating with high silica content reducing palatability for grazing animals throughout the year.

Antler rubbing sites of chital (Axis axis) were predominantly observed on small trees with slender girths, as shown in the image. During December to February, approximately 95% of chital stags sighted had antlers in velvet, with most transitioning to hard antlers by March and April.

“Shared Spaces”