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भारतीय वन्यजीव संस्थान
Wildlife Institute of India

**BY SPEED POST/ EMAIL**

**No. WII/RTI/CPIO/2020-21 (Qtr-IV)/103**

**Date: 17 March, 2021**

**To,**

**Himanshu Arora,**
**625, Street No. 4**
**Lane No. 9, Rajendra Nagar**
**Kaulhagarh Road, Dehradun**
**Email: himanshulife1313@gmail.com**
**Mob.: 9412009487**

**Sub.: Information under RTI Act, 2005–reg.**

**Ref.: Your Manual RTI No. -- dated 19/02/2021**

**Dear Shri Himanshu Arora,**

Please refer to your application cited above under RTI Act, 2005. In this context, the information sought by you has been collected from concerned authority of the Institute and and the same is attached herewith in 61 pages (Soft Copy) **(Annexure-I)**.

In case, you are not satisfied with the aforesaid reply, you may file an appeal to the First Appellate Authority indicated below within thirty days from the date of receipt of this letter:-

**Director, Wildlife Institute of India,**
**FAA & Director**
**Address: Wildlife Institute of India,**
**Post Box 18, Chandrabani,**
**Dehradun – 248 001, Ph. 0135-2640910".**

**Thanking you,**

17-3-2021

**NO & CPIO (RTI)**

**Encl.: as above.**

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AUGUST
2020

# Rapid Assessment of Wildlife and Suggested Mitigation Measures for Development of Delhi Dehradun Highway in the Shivalik Hills

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

TR. No. 2020/08

# RAPID ASSESSMENT OF WILDLIFE AND SUGGESTED MITIGATION MEASURES FOR DEVELOPMENT OF DELHI DEHRADUN HIGHWAY IN THE SHIVALIK HILLS

**Investigators**
Dr. Bivash Pandav
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भारतीय वन्यजीव संस्थान
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# *Acknowledgements*

Permission to carry out this work during the peak of lockdown period was promptly granted by the Chief Wildlife Wardens (CWLW) of Uttar Pradesh and Uttarakhand. We express our sincere gratitude to the CWLWs of both these states for allowing us to carry out the field sampling and greatly facilitating our work.

We express our sincere thanks to Dr. Dhananjai Mohan, Director, WII for his constant encouragement and critical review of the report. His knowledge of the area was of immense use in formulating this report.

Shri Sanjay Kumar, IAS, Commissioner, Sahranpur; Shri B. K. Jain, IFS, Chief Conservator of Forests, Saharanpur and Shri Amit Varma, IFS, Director, Rajaji Tiger Reserve constantly followed up our work and ensured necessary logistic support in the field. We thank the staff of: Shivalik Forest Division, UP; Chillawali and Ramgarh ranges of Rajaji Tiger Reserve; and Asarodi Range of Dehradun Forest Division for their support during the field work.

We thank the National Highway Authority of India for approaching us to carry out this study and for providing funding support to execute the work.

Nakul Markandey prepared all the maps. Akanksha Saxena helped us with the data analysis. We express our sincere thanks for their generous help.

Md. Yasin, Senior Technician and Bharat Singh, driver at WII worked tirelessly during the lockdown period, meticulously deployed and monitored all the 81 camera traps along the road. This work would not have been possible without their sincere efforts.

*Pic: Dr. Bivash Pandav*

# *Contents*



*Pic: Udaiveer Singh*

# *Executive Summary*

*The 20km stretch of NH72A between Ganeshpur and Dehradun passes through the wildlife rich habitats of Shivalik Forest Division, Uttar Pradesh and Rajaji Tiger Reserve as well as Dehradun Forest Division of Uttarakhand. This stretch of NH72A is being considered for expansion in order to provide better road connectivity between Delhi and Dehradun. Based on the request of National Highway Authority of India (NHAI), the Wildlife Institute of India (WII) carried out a rapid assessment of wildlife use along the road based on which appropriate mitigation measures are suggested in order to maintain the ecological integrity of the area. The road was categorized in to three distinct zones based on geographical and ecological features and 81 camera traps were deployed to sample the intensity of animal use in these three zones. To standardize the camera trap efforts, we determined the length of each road segment, and divided the species capture rates by the road length of each zone to get species capture rate per km length of road. Hotspots of animal use were generated using Kernel Density tool in ArcGIS Pro for all the camera trap points. We calculated the distance of the intensive use areas of heatmaps to get species specific and over all intensive crossing zones. We also identified consolidated crossing zones for important species and for species which are risky to human life/damage to vehicle owing to their large body size.*

*The overall per kilometer capture rate of wild animals was highest in Zone III (between Asarodi and Dehradun) among the three road stretches. This was largely due to abundance of primates (mainly rhesus macaques) on this stretch which largely remain on the highway owing to food provisioning by humans. However, per kilometer capture rates were highest for most other animal groups viz. pheasants (including red jungle fowl, peafowl and Kalij pheasant), ungulates (chital, sambar, nilgai, wild pig, barking deer), elephant, small mammals (including Indian crested porcupine and Indian hare) and leopard in Zone I (between Ganeshpur and Mohand) of NH 72A.*

*Based on the data generated, we suggest to elevate the road at least for a stretch of 3.5km in Zone I (between Ganeshpur and Mohand) with minimum of 7m height at the openings from the ground either in its existing alignment or in a new alignment along the river. The wildlife crossings in zone II (between Mohand and Asarodi) are largely taken care by the elevated road proposed by NHAI between Mohand and Dat Kali temple. We identified a 850m intensive animal use area in zone III (between Asarodi and Dehradun) and propose two Animal Under Passes of 200m each at critical crossing points.*

*Our study clearly indicates that this 20km stretch of NH72A passes through a wildlife rich area. Appropriate mitigation measures as suggested are a must in order to maintain ecological integrity of the area, which is part of high priority conservation landscape, both locally as well as globally.*

*The short-term study carried out by us only provides a snapshot of wildlife use of the area adjoining the road owing to the restricted duration of sampling.*

*Pic: Udaiveer Singh*

## Introduction:

Linear infrastructures such as roads, railway lines, canals, power lines, water and gas pipelines are known to adversely impact the biodiversity (Forman, 2003). Of the linear infrastructures, roads with increasing vehicular traffic pose a greater threat as they are ubiquitous in almost every landscape (Forman, 1998). The Indian protected area network is around 4.7 % of the total geographic area of the country (National Forest Commission, 2006). Also, majority of the PAs are small and isolated (National Forest Commission, 2006). To make the matters worse around 20,000 km of roads pass through our forested areas ( Annual report 2012-2013, Ministry of Road, Transport & Highways, Govt. of India). Development of linear infrastructure, especially roads, pose a major challenge owing to the wide-ranging impacts it can have on wildlife populations.

Roads and traffic affect wildlife populations in following ways- 1) habitat loss and degradation (Fahrig and Rytwinski, 2009) 2) wildlife mortality due to wildlife-vehicle collision (Forman, 2003) 3) acts as barrier ( Oxley et al., 1974 ; Mader, 1984 ; McGregor et al., 2008) 4) subdividing populations into smaller populations making them more vulnerable to local extinctions (Coffin, 2007). Apart from these, other effects of roads include changes in animal behaviour (Vidya and Thuppil, 2010 ; Mulero-Pazmany et al., 2015) and vegetation community along the road edges with introduction of invasive species (Davis et al., 2000), with these effects generally penetrating as long as 300m into the forest on each side of the road (Forman et al., 1997). Also, the roads passing through protected areas make the wildlife populations more susceptible to poaching and hunting owing to better access (Kerley et al., 2002; Mech et al. 1988; Brody 1984; McLellan & Shackleton 1988). Adverse effects of roads can escalate with increasing road width (Fahrig et al., 1995; Lovallo and Anderson, 1996) and traffic volume (Seiler 2003).

Extensive amount of work has been done to understand the ill effects of roads on ecosystems and landscape (Forman, 2003). Comprehensive books have been published which target multidisciplinary audience (scientists, engineers, planners, economists, transportation agencies) (Forman, 2003; van der Ree et al., 2015). Recently, the incorporation of remotely sensed data to understand the effects of roads has led to new insights and more precise estimates. For example, Torres et al. (2016) estimated that 22.4% and 50% of all land in Europe falls within 500m and 1.5km respectively from the nearest transport infrastructure. Similarly, D Amico et al. (2015) reports that roads caused a reduction of 40% of the regional habitat quality for red deer and 55% for wild boar. He also suggested that by decommissioning the unused and unpaved roads 91% of the potential habitat of both the species can be reclaimed. These figures indicate the level of adverse effects that roads can have on wild animal populations.

As a rapidly developing tropical country, India faces grave challenges in terms of conflict between its development goals and conservation of the remaining wildlife habitats. With the advancement of road ecology, there has been an increasing focus on developing roads with appropriate mitigation measures to reduce the deleterious effects of roads on wildlife. The present study was carried out with this background of understanding the wildlife use of an existing road and suggest mitigation measures as part of the proposed expansion of NH 72 connecting Delhi – Dehradun.


Dr. Bivash Pandav

**Background of the study:**

The existing National Highway 72 connects Delhi and Dehradun and is subjected to heavy vehicular traffic. Four laning of this highway is currently under progress. This existing highway also forms the part of a proposed new road project between Delhi and Dehradun that will significantly reduce the distance as well as travel time once it is ready. A 20 km stretch of this road between Ganeshpur in Uttar Pradesh (UP) and Dehradun passes through/along the wildlife rich forested habitats of Shivalik Forest Division in Uttar Pradesh, Rajaji Tiger Reserve (along the western most edge) and Dehradun Forest Division of Uttarakhand. Considering the wildlife value of the area, the National Highway Authority of India (NHAI) approached the Widlife Institute of India (WII) to carry out a rapid assessment of the wildlife use of this road and suggest mitigation measures to avoid negative impact of this road on wildlife of the area.

**Ecological setting of NH72 in the context of larger landscape:**

The 20 km stretch of NH72 between Ganeshpur and Mohand though largely passes through the Shivalik Forest Division of UP, ecologically, it abuts Rajaji Tiger Reserve and is a major road with considerable vehicular traffic in the western most part of Terai Arc Landscape (TAL), a major conservation landscape of the country. This stretch of road clearly bisects the contiguous forested tract between rivers Ganga and Yamuna that includes the entire western part of Rajaji Tiger Reserve, Shivalik Forest Division of UP, Dehradun and Kalsi Forest Divisions of Uttarakhand. Beyond Yamuna, this forest is contiguous with Kalesar National Park and Wildlife Sanctuary in Haryana and Sher Jung National Park in Himachal Pradesh (Figure 1). This contiguous forested tract happens to be the western most distribution limit of some of the endangered species such as tiger, elephant, king cobra and great hornbill (Johnsingh et al. 2004). As recent as 2004, tiger presence was recorded in this entire landscape (Johnsingh et al. 2004). The tiger population though depleted at the moment in western part of Rajaji Tiger Reserve, the authorities are currently embarking on an ambitious tiger recovery program (Harihar et al. 2014). With the possible recovery of tiger population in Western Rajaji in the near future, tigers will soon regain their former range along this western most part of TAL. Therefore, maintaining the integrity of this landscape is an absolute necessity for achieving future conservation goals. The proposed expansion of NH72 assumes great significance in this context. With appropriate mitigation measures at right places in this proposed expansion program, there is a great opportunity at hand to demonstrate the synergy between development and conservation.

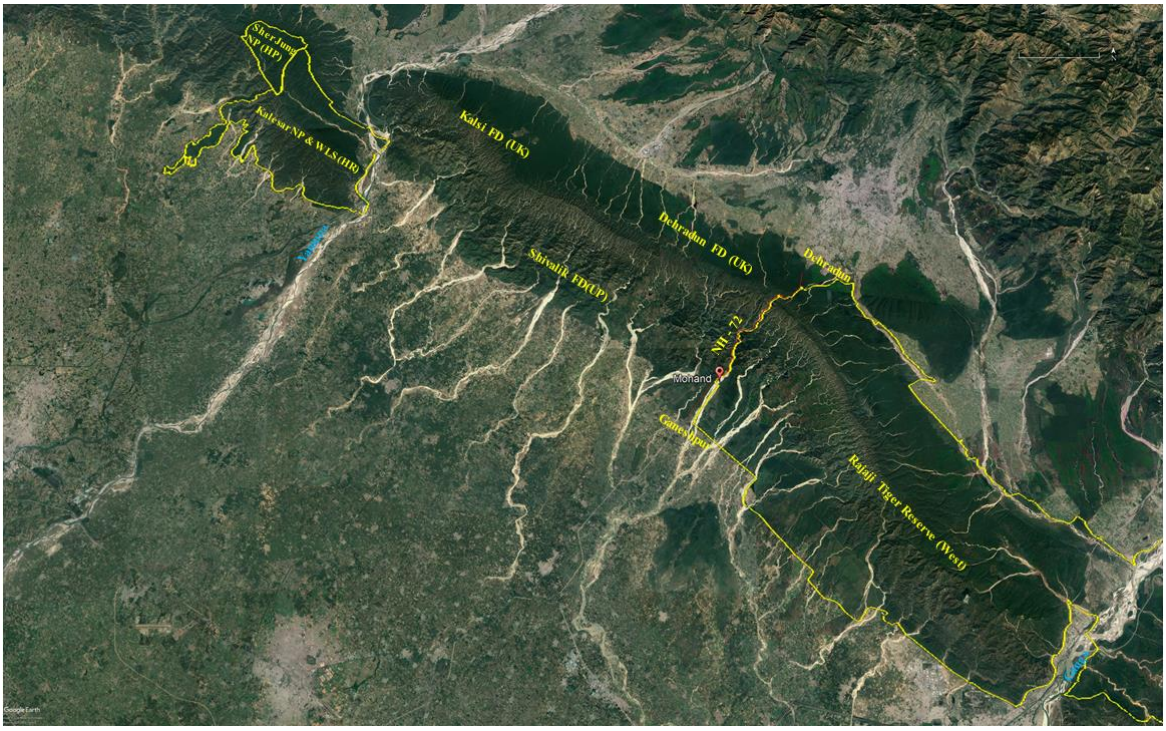


**Figure 1:** Map showing the 20 km stretch of NH72 between Ganeshpur and Mohand that bisects the forested landscape between rivers Ganga and Yamuna along the westernmost part of Terai Arc Landscape.

**Description of the road:**

Detailed study was carried out in the 20km stretch of NH72 between Ganeshpur and Dehradun. The road in this 20km stretch can be broadly classified in to three distinct zones based on their geographical features (Figure 2).

Zone I (4.9km) from Ganeshpur to Mohand, passes through flat terrain and lies entirely in Shivalik Forest Division (Mohand Range, Budhaban and part of Mohand beat) Uttar Pradesh. Right side (eastern side) of the road in this zone is characterized by extensive riverine vegetation such as *Acacia catechu* and *Holoptelea integrifolia*. This stretch is also dominated by miscelaneous tree specis such as *Haldina cordifolia*, *Crataeva religiosa*, *Garuga pinnata*, *Toona ciliata*, *Terminalia tomentosa*, *T. bellerica*, *Hymenodictyon excelsum* and *Ficus benghalensis*. Left side (western side) of the road in this zone is dominated by Teak (*Tectona grandis*) plantations. Middlestorey in this zone is dominated by *Mallotus philippensis* and *Holarrhena antidysenterica*. *Justicia adhatoda* dominates the understorey.

Zone II (13.3 km) starts couple of hundred meters before the Mohand settlement (immediately after the Mohand Forest Rest House of Shivalik Forest Division, UP) and extends all the way up to Asarodi police checkpost in Uttarakhand. This zone is characterized by hilly terrain. The initial 3.9 km stretch of this road, from Mohand till the iron bridge near Thandi Sot (Sot for seasonal water channel), passes through Mohand beat of Mohand range, Shivalik Forest Division, UP. Thereafter, till the tunnel near Dat Kali temple, the road though in Shivalik Forest Division, UP, forms the boundary of Rajaji Tiger

Reserve (Mohand and Pathar Sot beats of Chillawali Range). After the tunnel the road in this zone follows Rajaji Tiger Reserve (Asarodi beat of Ramgarh Range) on its right and Dehradun Forest Division (Asarodi Range) on its left till the Asarodi police checkpost. Vegetation on the hill slopes along this zone is dominated by *T. tomentosa* and *Anogeissus latifolia*. Sal (*Shorea robusta*) occurs in extremely low density in this zone. Hill tops in this stretch are characterized by *Pinus roxburghii*. Moist valleys in this zone are dominated by tree species such as *Syzigium cumini* and *Olea glandulifera*. *Ficus glomerata* and *F. semicaudata* grow commonly along the riverine tracts in this zone. Two of the endemic plants of Shivaliks, *Eremostachys superba* and *Catamixis baccharoides* occur along the road in this zone.

Zone III (1.8 km) starts from the Asarodi police checkpost and extends upto the edge of Mohbewala settlement in Doon valley. The road in this zone passes through flat terrain. Vegetation in this zone is completely dominated by Sal trees with unpalatable species such as Murraya koenigii, Ardisia solanacea and Clerodendron infortunatum dominating the understorey.

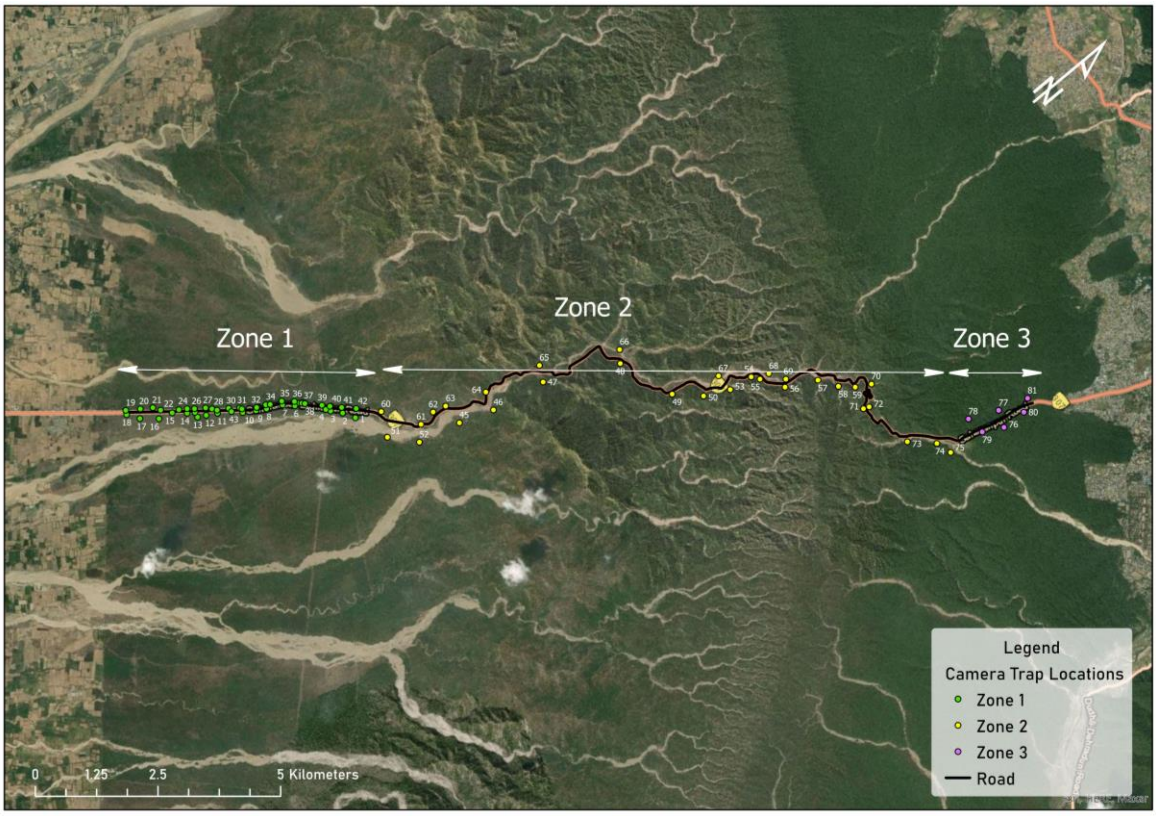


**Figure 2**: The three zones of the 20 km stretch of road between Ganeshpur and Mohand showing the location of camera traps deployed during the study in each of the zones. 44 camera traps were deployed in Zone I, followed by 31 in Zone II and six in Zone III.

**Methods:**

Field work for the study was initiated during the lockdown period from 25 April and field sampling was carried out till 04 July 2020. An attempt was made to identify all the animal trails on both sides of this road. 81 camera traps (single side) were deployed along these identified trails to detect wild animals using the area and crossing events (Figure 2). Camera

traps were regularly monitored, and data was periodically downloaded from them during the sampling period.

**Analytical Methods:**

### *I. Standardization of camera trap efforts*

Data of number of captures of elephant, leopard, lesser carnivores, ungulates, small mammals and pheasants in all three zones were pooled to yield the total captures in each zone. The species/group specific capture rates were calculated by dividing the total captures by the trapping effort (defined as the product of the total number of cameras deployed on each zones and the average number of days the cameras were operational). To generate standardized estimates of species capture rates for comparison between road zones (1, 2 and 3), we determined the length of each road segment, and divided the species capture rates by the road length of each zone to get species capture rate per km length of road.

### *II. Identification of animal crossing zones*

To get an index of intensity of use of area or segment of the road for crossing, the heatmap of the capture locations was generated using Kernel Density tool in ArcGIS Pro for all the camera trap points. Kernel analysis is a non-parametric statistical tool for estimating probability densities from set of points. This method begins by centering a bivariate probability density function with unit volume (i.e., the kernel) over each recorded points. A bivariate kernel probability density estimator (i.e., a "utilization distribution") is then calculated using the probability density estimates at each capture. The resulting kernel probability density estimator will have relatively large values in areas with many captures and low values in areas with few captures. Intensive use area estimates were derived by drawing contour lines (i.e., isopleths) based on the summed volumes of the kernels at these points. These isopleths define intensive use areas at different probability levels whose areas can be calculated. This was used to identify specific animal crossing zones along the road stretch. For each species and for groups of species (Table 1), total number of captures were used as a weight to determine the density along with their location. To determine vulnerable crossing zones for all the species, we calculated the distance of the intensive use areas of heatmaps to get species specific and over all intensive crossing zone. The crossing zones were classified into major and minor based on the intensity of animal captures. We also identified consolidated crossing zone for important species and for species which are risky to human life/damage to vehicle owing to their large body size.

**Table 1:** Animal groups considered for analysis for the present study

| *Group* | *Species included* |
|---|---|
| **Lesser carnivores** | Jackal<br>Jungle cat<br>Rusty spotted cat<br>Asian palm civet<br>Small Indian civet<br>Yellow-throated marten<br>Masked palm civet<br>Gray mongoose<br>Leopard cat<br>Monitor lizard |
| **Large Carnivores** | Leopard |
| **Small mammalian herbivores** | Indian crested porcupine<br>Indian hare |
| **Ungulates** | Spotted deer (chital)<br>Sambar<br>Nilgai (bluebull)<br>Wild pig<br>Barking deer<br>Himalayan gray goral |
| **Primates** | Gray langur<br>Rhesus macaque |
| **Pheasants** | Red junglefowl<br>Peafowl<br>Khalij pheasant |
| **Elephants** | Asian Elephant |

**Results:**

We deployed a total of 81 cameras on NH 72 yielding a total effort of 3294.45 trap days in the entire study stretch of 20 km. We obtained a total of 33,722 images of humans, domestic and wild animals. Of these, 17,010 captures were of 25 wild species (Annexure I). Leopards were photo captured in 39 of the 81 camera traps deployed along the road resulting in 96 images (52 left flank and 44 right flank). For Individual identification of leopards, we considered only left flank (owing to larger number of photographs). A total of fourteen unique individual leopards were identified in the 20 km stretch of NH 72A (Annexure II). Photo capture locations of these 14 leopards are depicted in Figure 3.

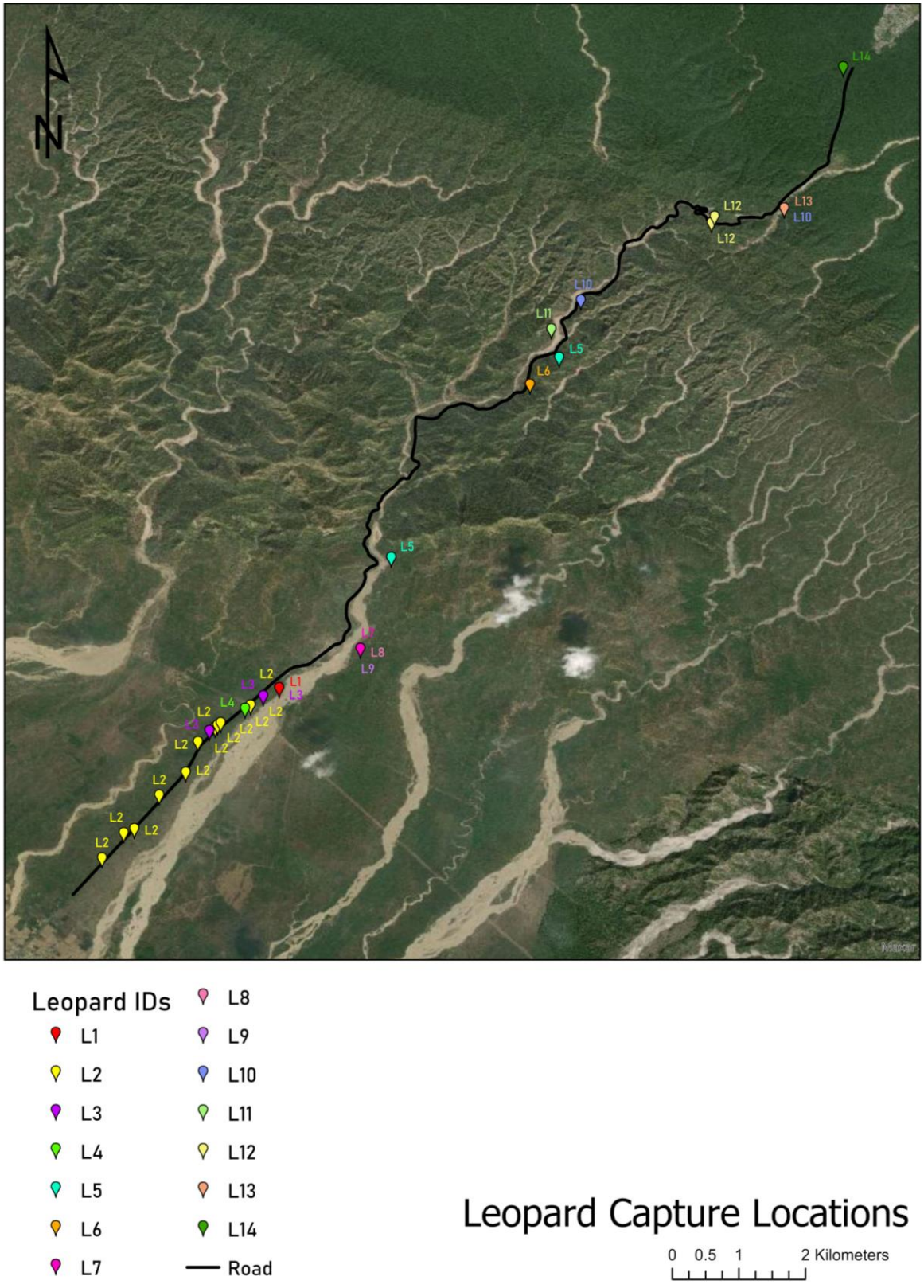


**Figure 3**: Spatial location of 14 individual leopards identified from 25 locations along NH72 between Ganeshpur and Dehradun.

## *I. Standardization of Camera Trap Efforts*

The overall per kilometre capture rate in Zone III was the highest among the three road stretches (Figure 4). This was largely due to abundance of primates on this stretch which largely remain on the highway owing to food provisioning by humans. However, per kilometre capture rates were highest for pheasants (including red junglefowl, peafowl and Kalij pheasant), ungulates (chital, sambar, nilgai, wild pig, Himalayan goral, barking deer), elephant, small mammals (including Indian crested porcupine and Indian hare) and leopard in Zone I of the study area.

Lesser carnivores, classified as carnivorous animals weighing less than 15 kg including jackal, rusty spotted cat, Asian palm civet, small Indian civet, yellow-throated marten, Masked palm civet, gray mongoose, leopard cat and monitor lizard, had the highest capture rates in Zone III.

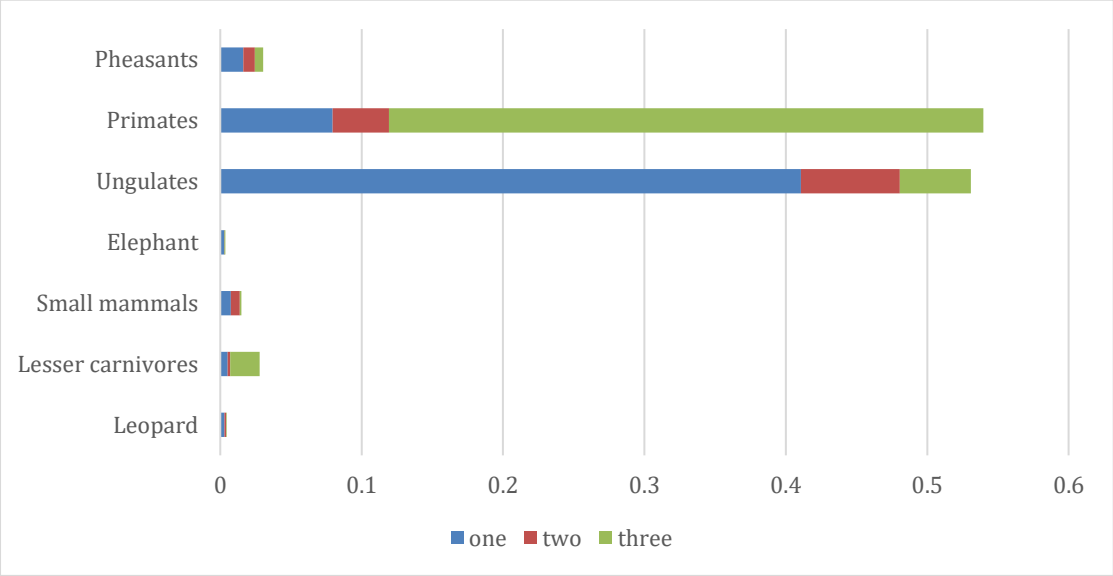


**Figure 4:** Per kilometre capture rates of different animal groups on the three zones I (blue), II (red) and III (green) on NH 72.

Large-bodied animals (weighing >15 kg) like barking deer, wild pig, nilgai, sambar, chital, leopard and elephant were found to be more abundant in Zone I (Figure 5).

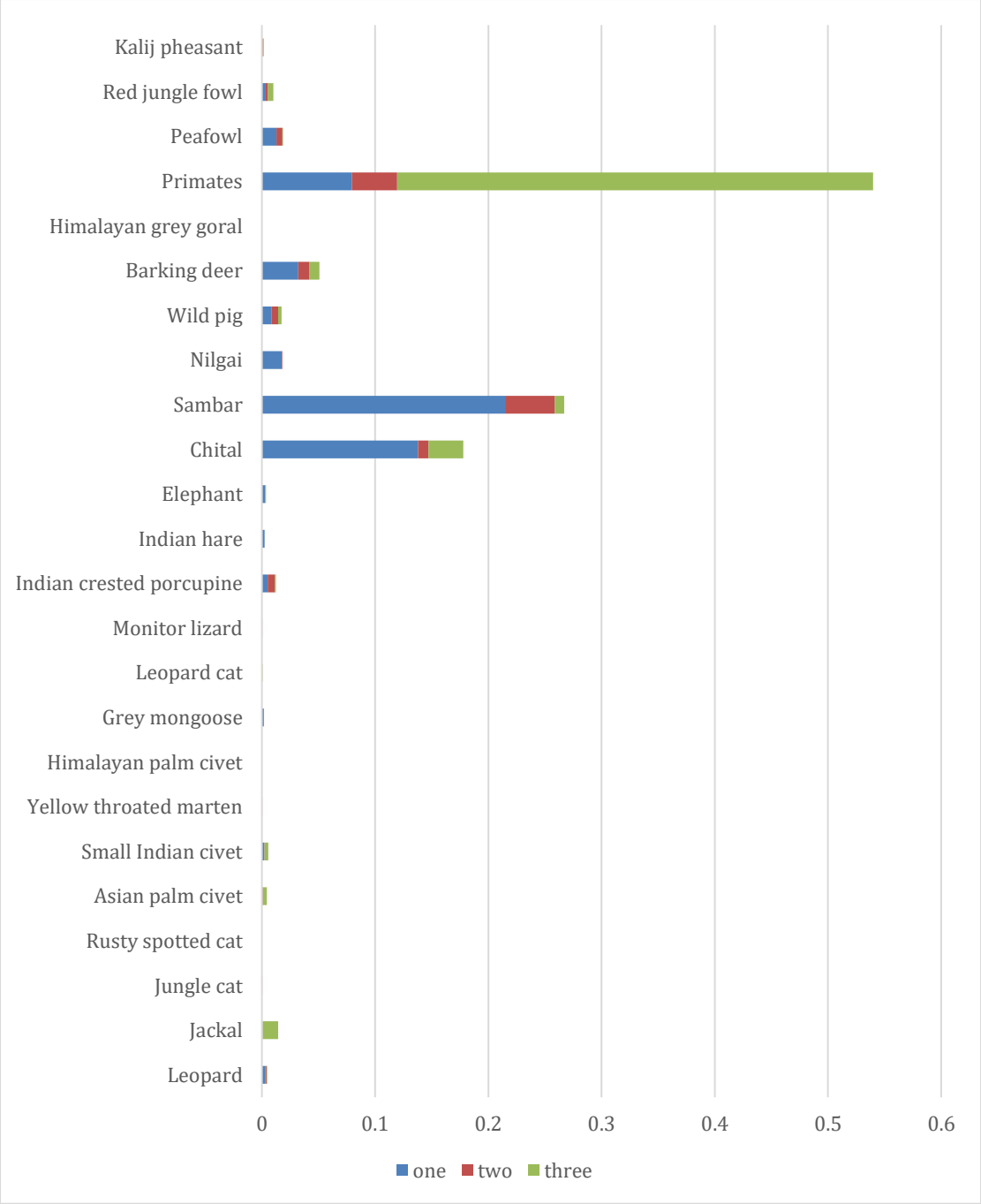


**Figure 5:** Per kilometre capture rates of all species on three zones of NH 72 (gray langur and rhesus macaque have been pooled together as primates).

## I. Identification of Species-Specific Crossing Zones

### a. Leopard

Highest leopard captures were obtained from Zone I, followed by Zone II and the least from Zone III. Based on the intensity of captures of leopard on both sides of NH 72 on the three road patches, one 3200 m wide crossing zone on Zone I, and one crossing zone measuring 1800 m on Zone II can be identified (Figure 6).

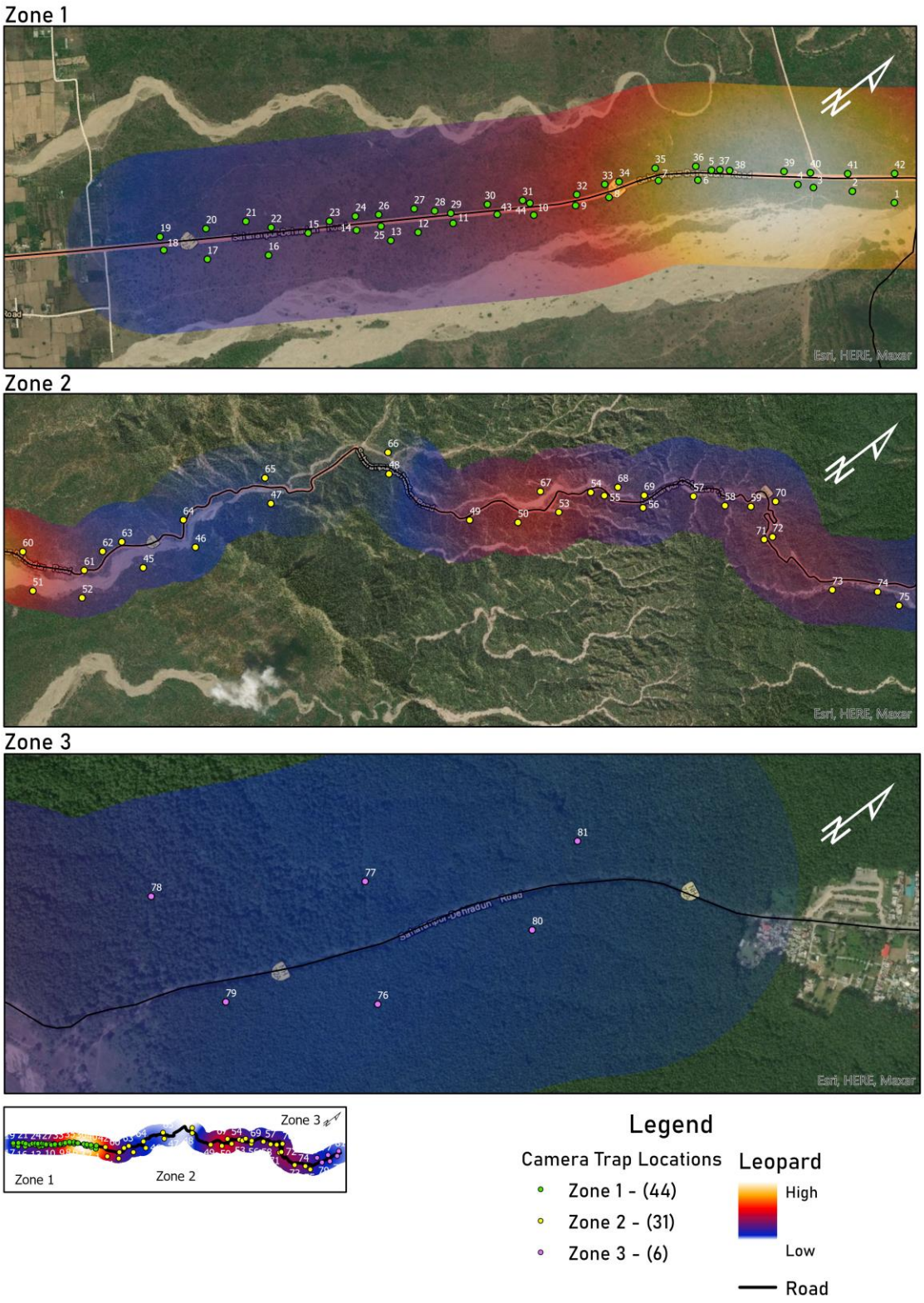


**Figure 6:** Kernel density maps based on intensity of captures of leopard on road zones I, II and III on NH 72 between Ganeshpur and Dehradun.

## b. Lesser carnivores

Highest captures of lesser carnivores were obtained from Zone III, followed by Zone I and the least from Zone II. Based on the intensity of lesser carnivore captures on both sides of NH 72 on the three road patches, one 2800 m wide crossing zone on Zone I, one crossing zone measuring 1100 m on Zone II, and almost the entire length of Zone III (1800 m) can be identified (Figure 7).

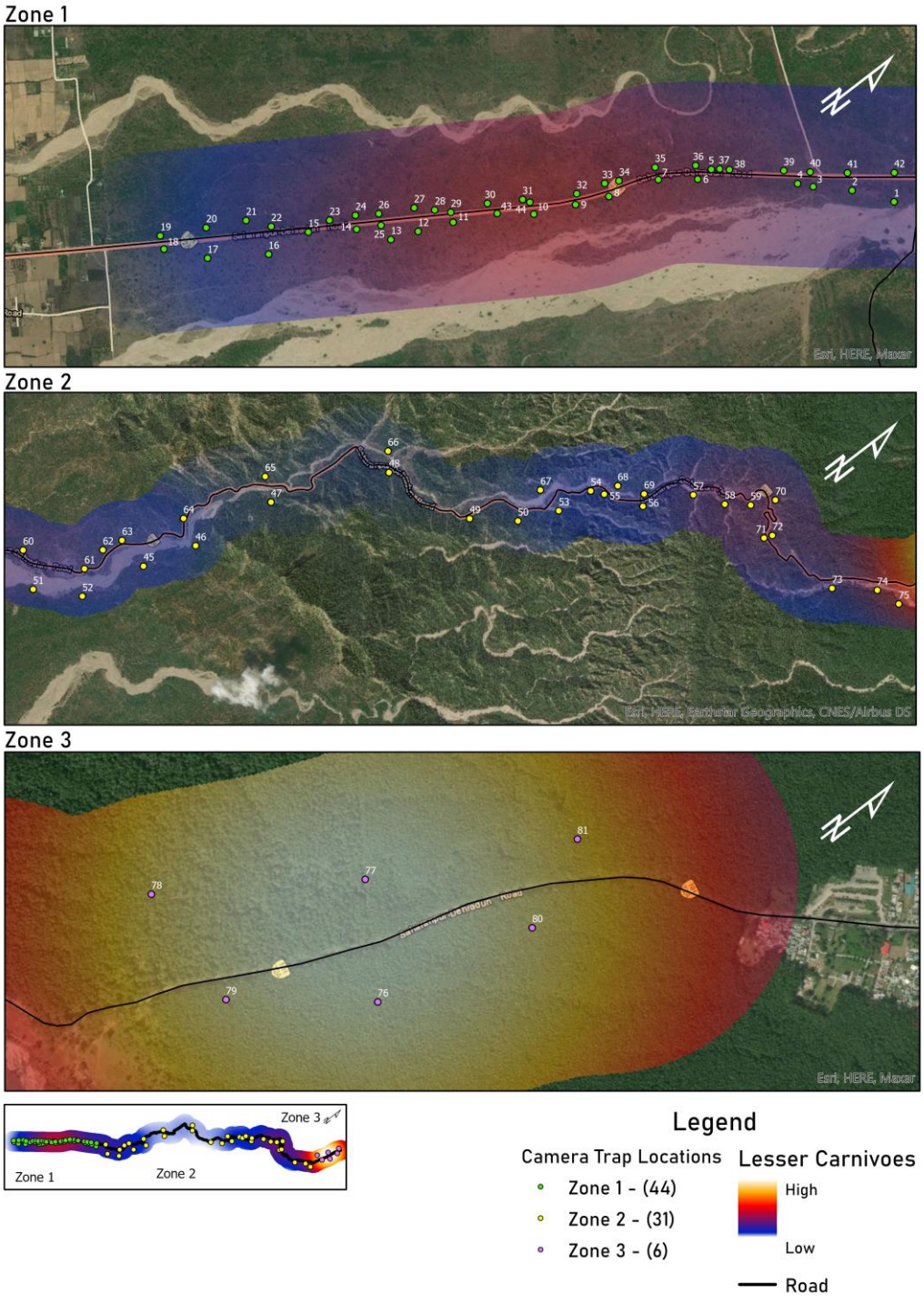


**Figure 7:** Kernel density maps based on intensity of captures of lesser carnivores on road zones I, II and III between Ganeshpur and Dehradun.

### c. Small mammalian herbivores (Indian hare and Indian crested porcupine)

Highest captures of Indian hare and Indian crested porcupine were obtained from Zone I, followed by Zone II and the least from Zone III. Hare was captured only in Zone I of the road. Based on the intensity of small mammal captures on both sides of NH 72 on the three road zones, almost the entire length of Zone I (4900 m), and two crossing zones measuring 1900 m and 6800 m (almost contiguous stretch) on Zone II can be identified (Figure 8).

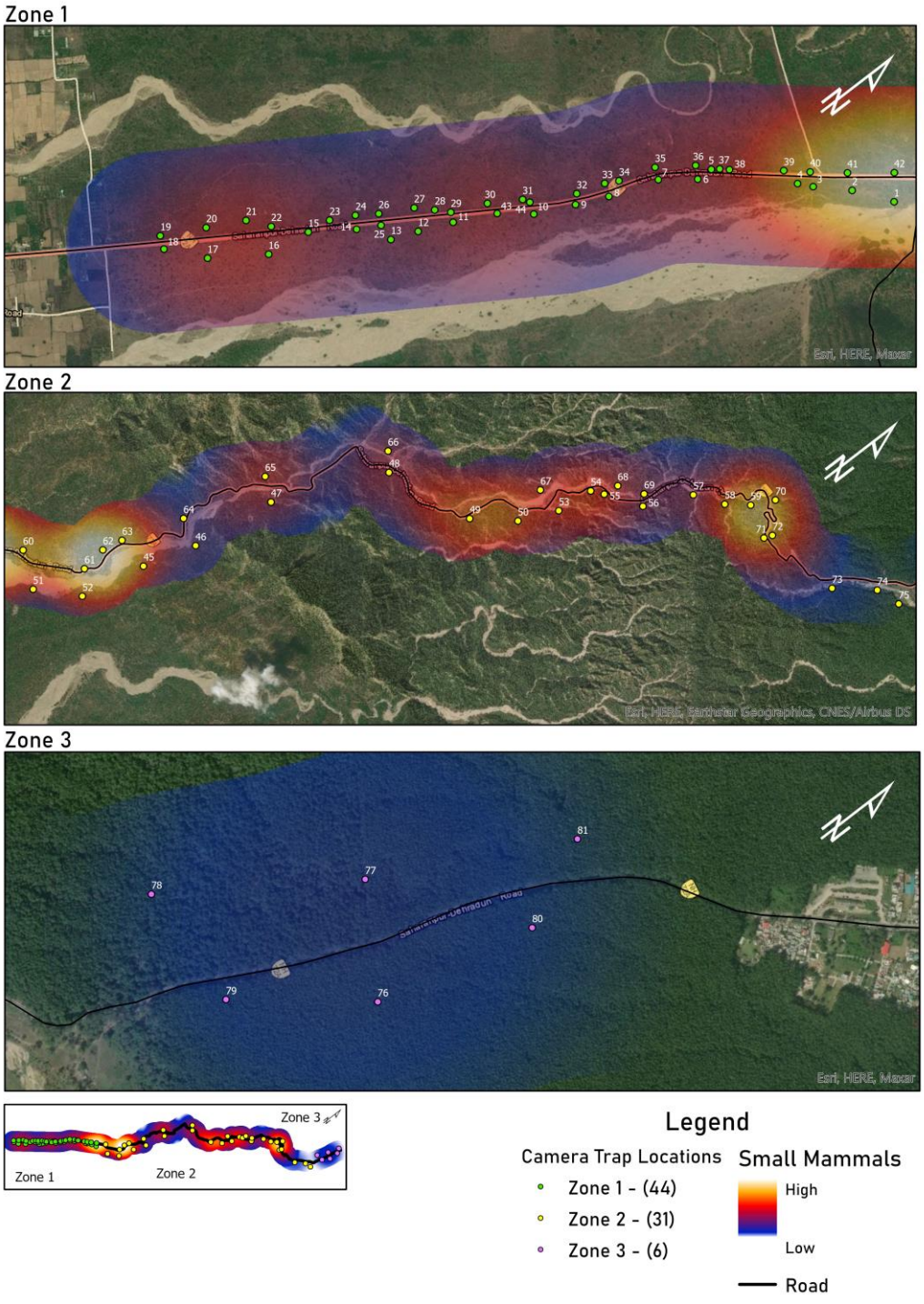


**Figure 8:** Kernel density maps based on intensity of captures of small mammalian species on road zones I, II and III on NH 72 between Ganeshpur and Mohand.

### d. Asian elephant

Highest captures of Asian elephant were obtained in Zone I, followed by Zone II and the least from Zone III. Based on the intensity of elephant captures on both sides of NH 72 on the three road zones, one major crossing zone measuring 3100 m in Zone I, two minor (with respect to intensity of elephant capture) crossing zones measuring 1000 m in Zone II and 800 m in Zone III can be identified (Figure 9).

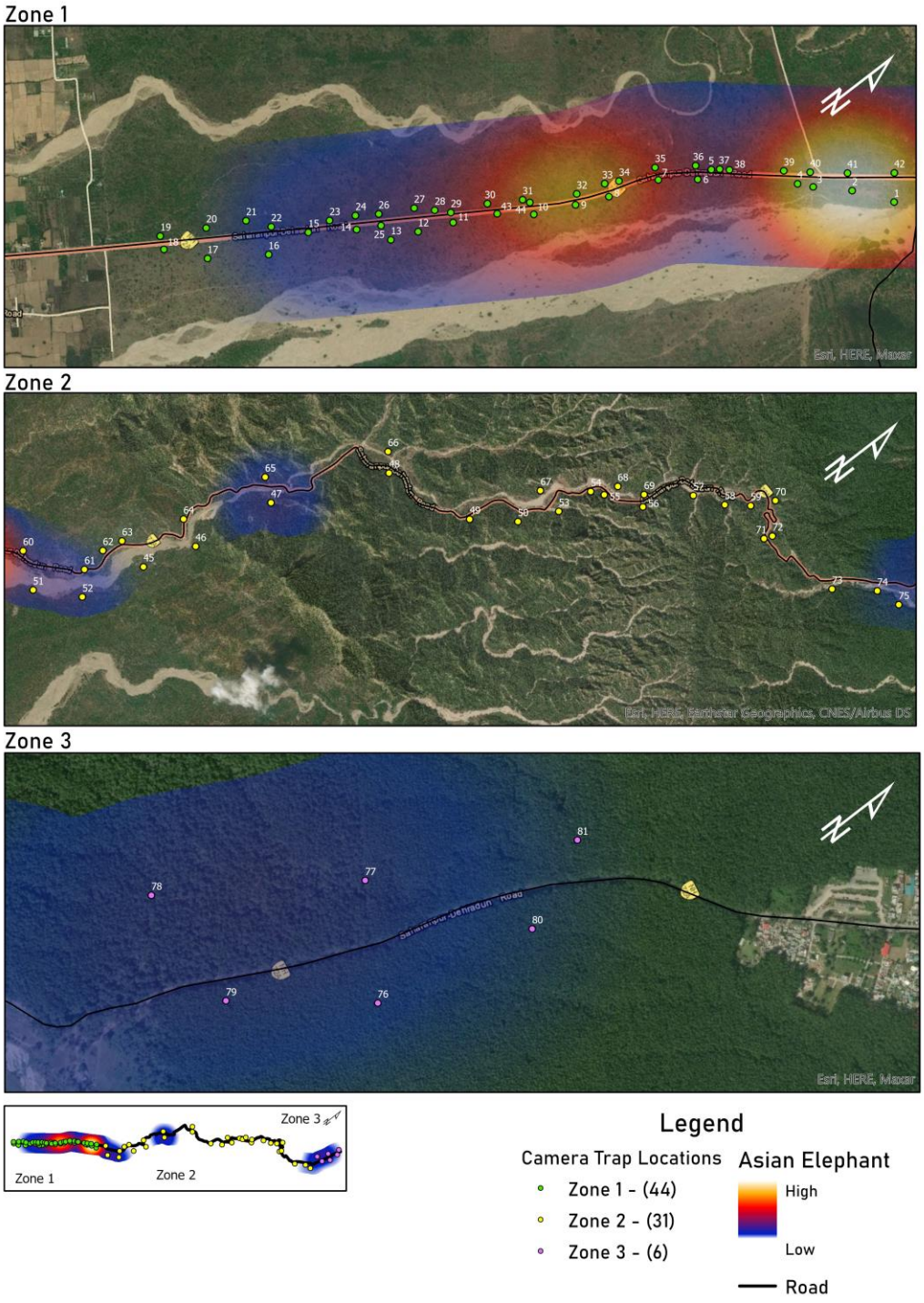


**Figure 9:** Kernel density maps based on intensity of captures of Asian elephant on road zones I, II and III on NH 72 between Ganeshpur and Mohand.

## e. Ungulates

Highest captures of ungulates were obtained from Zone I, followed by Zone II and the least from Zone III. Based on the intensity of ungulate captures on both sides of NH 72 on the three road zones, one major crossing zone measuring 3200 m in Zone I, several minor crossing zones in Zone II (ranging from 300-650 m in width) and one minor crossing zone (400 m)in Zone III can be identified (Figure 10).

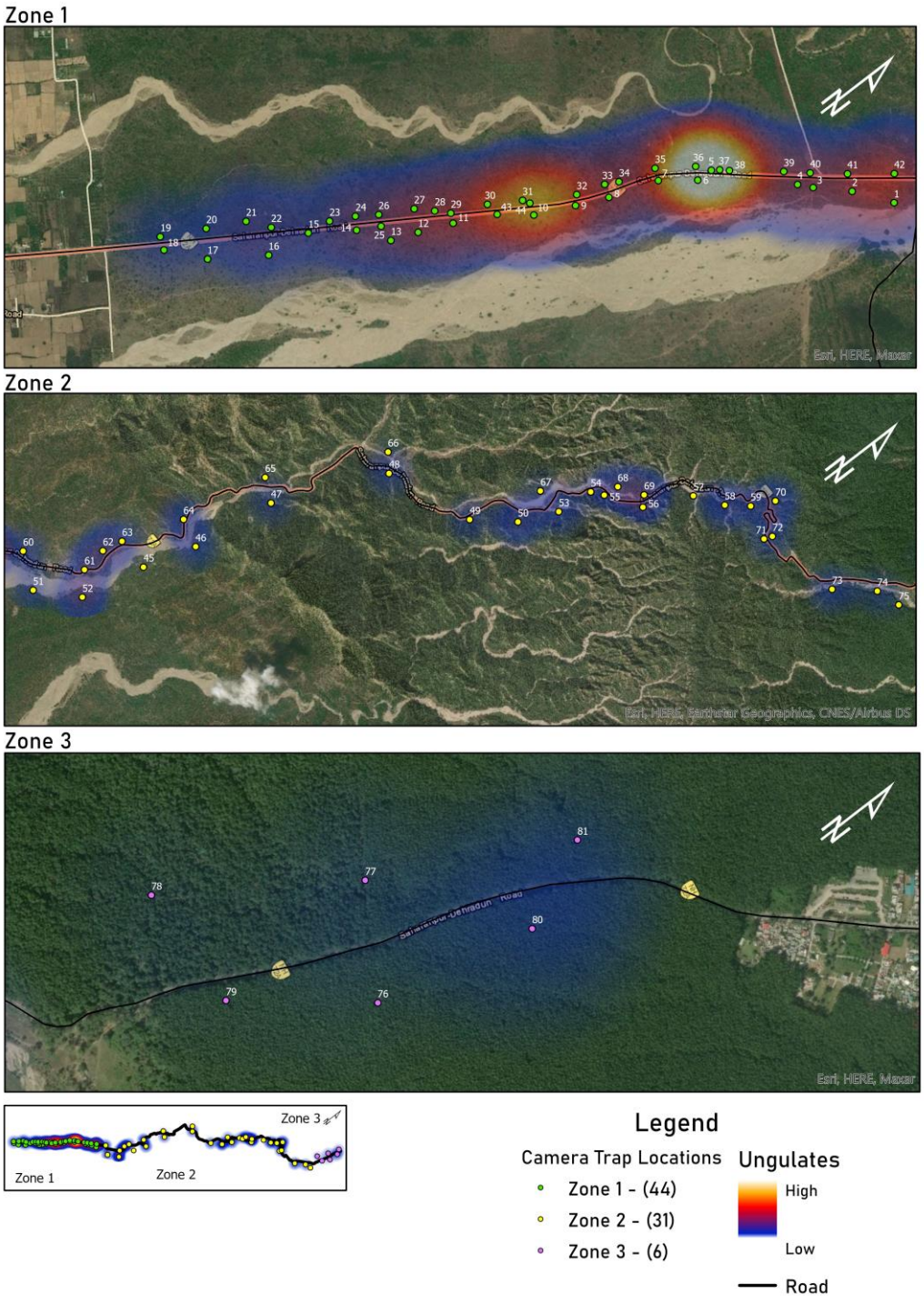


**Figure 10**: Kernel density maps based on intensity of captures of ungulates on road Zones I, II and III on NH 72 between Ganeshpur and Dehradun.

### *f. Primates (Indian langur and rhesus macaque)*

Primates are abundant all along the stretch of NH 72, primarily due to food provisioning. Highest captures of primates were obtained from Zone III, followed by Zone I and the least from Zone II. Based on the intensity of primate captures on both sides of NH 72 on the three road zones, almost the entire stretch of Zone I, one in Zone II (600 m) and one crossing zone (1300 m) in Zone III can be identified (Figure 11).

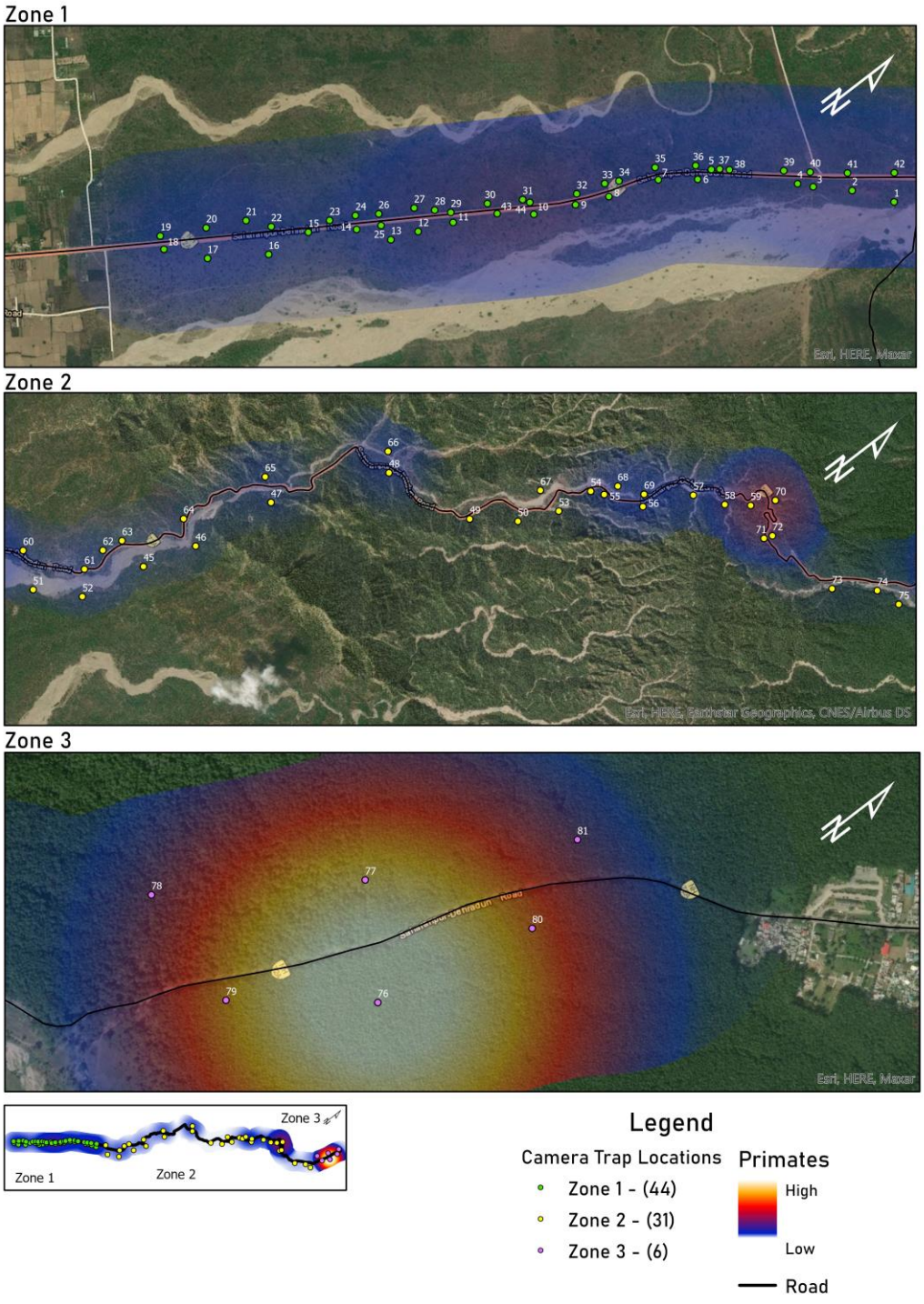


**Figure 11:** Kernel density maps based on intensity of captures of Indian gray langur and rhesus macaque on road zones I, II and III on NH 72 between Ganeshpur and Dehradun.

### *g. Pheasants*

Highest captures of pheasants were obtained from Zone I, followed by Zone II and the least from Zone III. Based on the intensity of pheasant captures on both sides of NH 72 on the three road patches, one major crossing zone measuring 4500 m in Zone I, two major crossing zones in Zone II (1700 m and 2800 m) and one minor crossing zone (800 m) in Zone III can be identified (Figure 12).

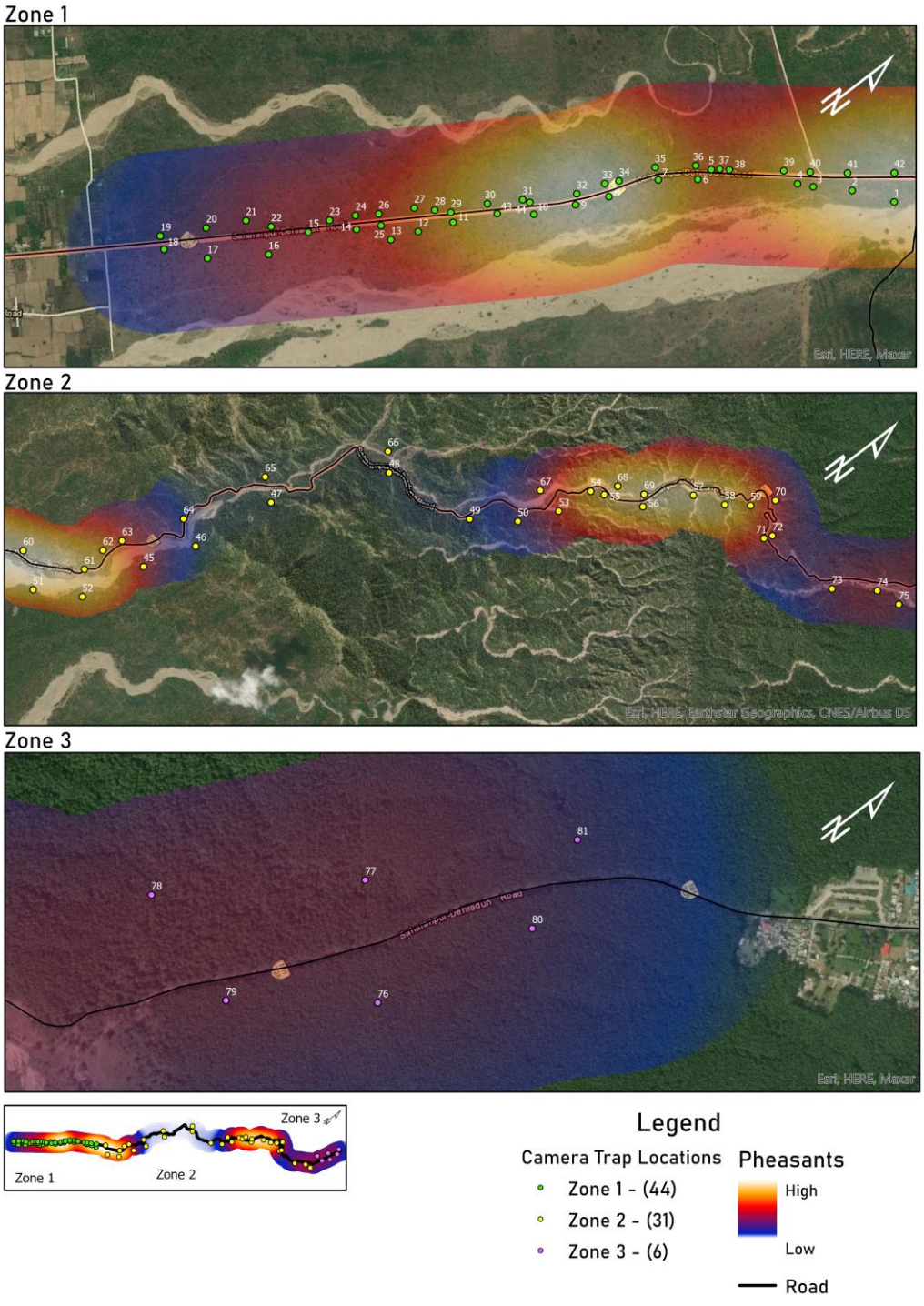


**Figure 12**: Kernel density maps based on intensity of captures of pheasants on road zones I, II and III on NH 72 between Ganeshpur and Dehradun.

### *h. Consolidated crossing zone for multiple species on NH 72*

All species of wild animals camera trapped during the study were found intensively using bulk of the Zone I. Based on high intensity of animal use, a continuous stretch of 3,500m in zone I, two stretches of 3,000m and 4,000m in zone II and one stretch of 850m were identified in Zone III (Figure 13).

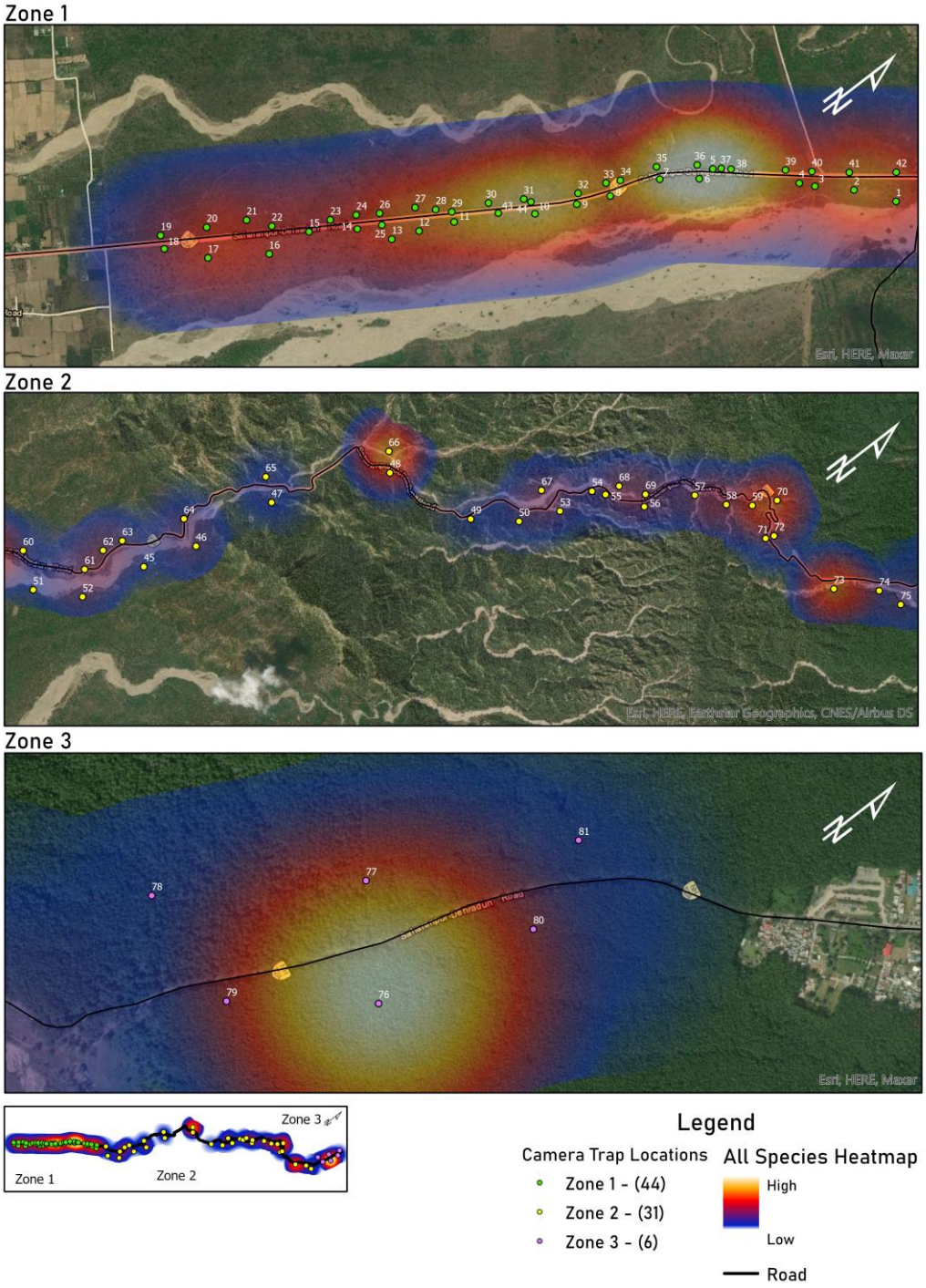


**Figure 13:** Kernel density maps based on intensity of captures of all wild animals on road zones I, II and III on NH 72 between Ganeshpur and Mohand.

**Proposed Mitigation Measures:**

As is evident from the results of this study, the 20 km stretch of NH72 between Ganeshpur and Dehradun passes through an extraordinarily rich wildlife area. Proximity of this road to Rajaji Tiger Reserve and the adjoining wildlife rich area of Shivalik Forest Division, UP (Johnsingh et al. 2004) are largely responsible for this rich assemblage of wildlife species along this stretch of road. Any mitigation measures proposed as part of expansion of this stretch of highway needs careful consideration. Based on the intensity of captures of all wild animals on the three zones of NH 72 between Ganeshpur and Dehradun, wildlife crossing zones were demarcated. The details of these crossing zones where mitigation measures may be built are provided below (Table 2 and Figure 14).

**Table 2:** Details of wildlife crossing zones on NH 72.

| *Zone/Patch* | *Crossing zone number* | *Mid-point of crossing zone* | *Length of crossing zone (m)* |
|---|---|---|---|
| **1** | 1 | 77.8927 E<br>30.1698 N | 3500 |
| **2** | 1 | 77.9108 E<br>30.1870 N | 3000 |
| | 2 | 77.9544 E<br>30.2398 N | 4000 |
| **3** | 1 | 77.9767 E<br>30.2532 N | 850 |

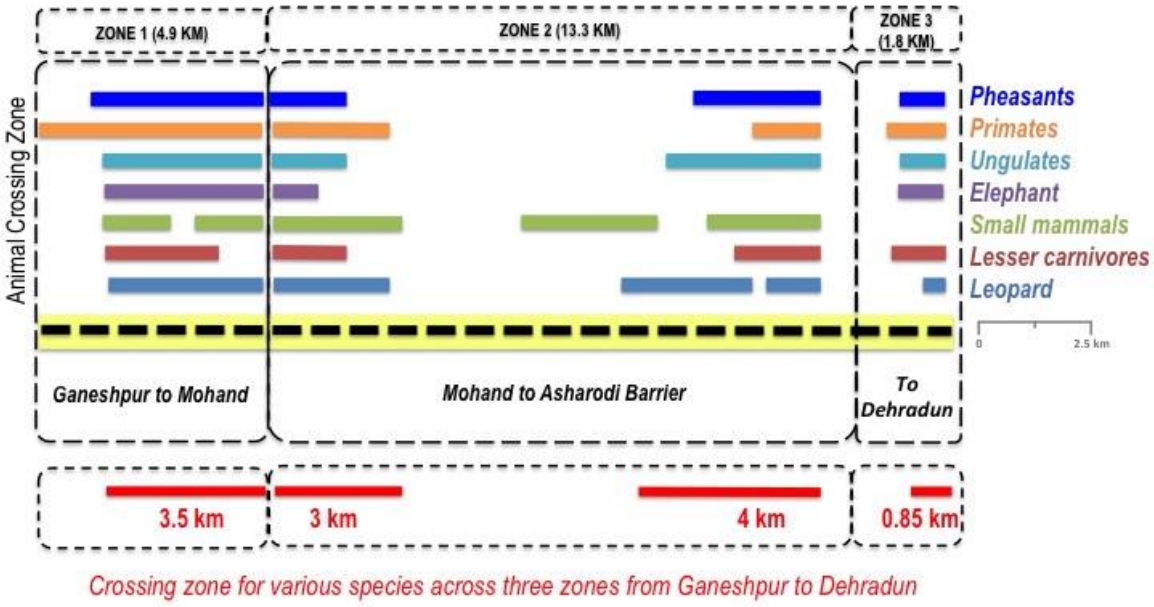


**Figure 14:** Schematic diagram depicting critical crossing zones of all species on the 20 km stretch between Ganeshpur and Dehradun on NH72.

**a. Zone I as a critical section for mitigation:**

Wild animal mortality due to collisions with vehicles are a threat to biodiversity, and are among the major threats to animals in human-dominated landscapes. However, collisions of vehicles with large-bodied animals can also be a threat to the safety of humans, and also has economic implications. While data on wild large mammal-driven road accidents are not available for India, the number of large mammal-vehicle collisions in the United States and Europe has been estimated at 1-2 million and 507,00 (Huijser et al. 2008) respectively. These kinds of fatal accidents mostly occur in rural areas adjoining forests where large mammals are abundant. These cases could also result in road authorities being held accountable for the loss of life and property (Abra et al., 2019).

Given that NH 72 abuts the Rajaji National Park that is abundant in large mammals such as the Asiatic elephant, sambar, chital, nilgai, leopard and wild pigs, the potential fatality and injury risk to humans and damage to vehicles as a result of collision cannot be ruled out. Moreover, 91% of captures of wild animals near the road were of large mammals that have the potential to cause accidents fatal for human. It is therefore imminent to align the goal mitigation on NH 72 not only for wild animal safety and connectivity, but also to reduce risks to human safety. Similar approach has been used earlier for proposing the world's largest and India's first ever mitigation measures on NH 7 (now NH 44) passing through important wildlife areas near Pench Tiger Reserve, Maharashtra India (Habib et al., 2015; 2016). The mitigation measures have been proved to be effective and in last nine months till December 2019 a total of 18 wild animal species were found to use underpasses resulting in 5450 captures including 89 captures of 11 unique individual tigers (Habib and Saxena 2020).

Considering the above mentioned large bodied animals only, of the 4.9 km stretch of Zone I on NH 72, about 3.5 km of the road is considered high risk with respect to risk of large mammal-vehicle collisions that could result in human fatalities (Figure 15). This is a flat segment of the road which is also critical as a crossing zone for wildlife that are endangered, vulnerable and near threatened.

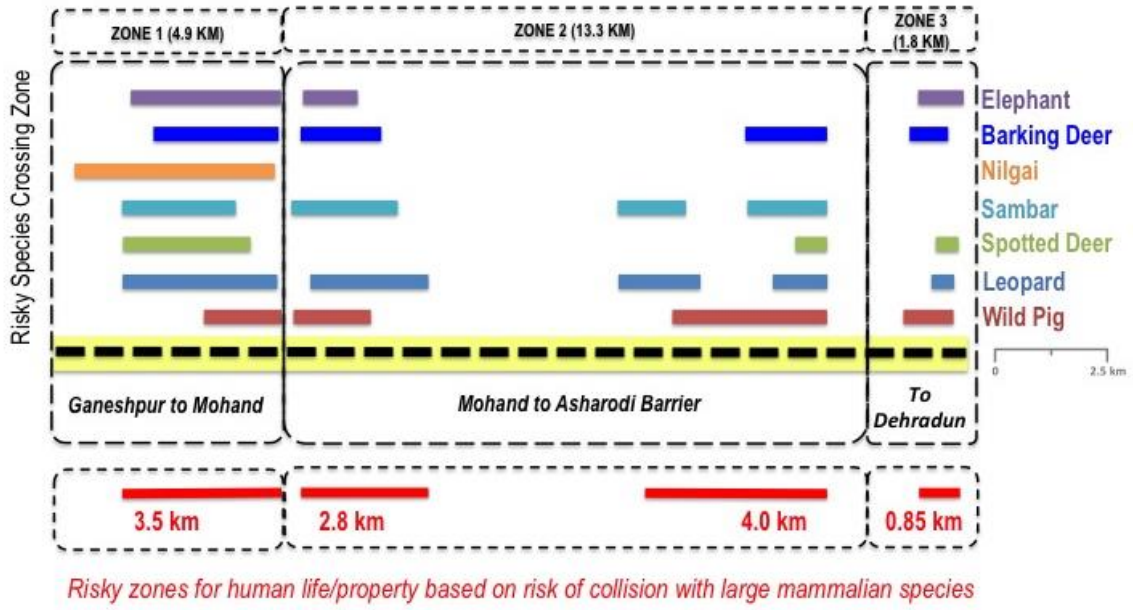


**Figure 15:** High risk area with respect to fatal wildlife-vehicle collisions from human safety and wildlife perspectives on the three zones of NH 72

It is therefore suggested that a contiguous crossing structuren(Animal Under Pass) be provided in this critical road segment. The minimum length of the structure should be 3,500 m (opening of about 3200m) with at least 7m height from the ground either on the existing alignment or on a new alignment. The remaining stretch of road in this zone should have barrier walls of adequate height (ca. 3m with a trapezoidal cross-section) to help animals funnel through the underpass. Possibility of exploring an alternate alignment on the river bed (Mohand rau) should be attempted and the road can be elevated in Zone I after 1.4 km from the forest boundary (from Ganeshpur).

### b. Mitigation measures in Zone II

Two stretches of 2.8km (immediately after Mohand) and 4.0km (ending with the tunnel near Dat Kali) were identified as critical wildlife crossing zones in this stretch. A large part of this second wildlife crossing zone is attributed to the ridge line above the existing tunnel that already facilitates lot of animal movement. As per the plan provided by NHAI, it is understood that a large section of this stretch in Zone II will be an elevated structure that also takes care of the critical wildlife crossings and any additional structure may not be required.

### c. Mitigation measures in Zone III

One stretch of 850m was identified as a critical wildlife crossing zone in this section of the road. It is proposed to have an 850m of integrated structure with at least two openings of 200m each (Animal Under Pass with minimum of 7m height from the ground) at the designated sites (Location I - N30°15’07.76” E77°58’35.80” and Location II – N30°15’25.41” E77°58’39.76”).

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**Notes:**

## ANNEXURE I

## Details of the 25 species camera trapped during the study


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Common Leopard | *Panthera pardus* | 49 | 44 | 3 | 96 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Nilgai | *Boselaphus tragcamelus* | 283 | 23 | 0 | 245 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Sambar | *Rusa uniocolor* | 3467 | 1931 | 48 | 5446 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Chital | *Axis axis* | 2228 | 405 | 181 | 2417 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Barking Deer | *Muntiacus muntjak* | 517 | 441 | 52 | 1010 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Goral | *Naemorhedus goral* | 0 | 2 | 0 | 02 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Wild pig | *Sus scrofa* | 134 | 261 | 18 | 413 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Jackal | *Canis aureus* | 5 | 17 | 81 | 103 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Indian Crested Porcupine | *Hystrix indica* | 83 | 269 | 7 | 359 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Leopard Cat | *Prionailurus bengalensis* | 0 | 8 | 3 | 11 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Jungle Cat | *Felis chaus* | 3 | 1 | 0 | 04 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Small Indian Civet | *Viverricula indica* | 34 | 17 | 19 | 70 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Asian Palm Civet | *Paradoxurus hermaphrodites* | 7 | 21 | 20 | 48 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Masked Palm Civet | *Paguma larvata* | 0 | 3 | 0 | 3 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Yellow Throated Marten | *Martes flavigula* | 1 | 8 | 0 | 9 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Indian grey mongoose | *Herpestes edwardsii* | 28 | 2 | 0 | 30 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Asian Elephant | *Elephas maximas* | 46 | 9 | 4 | 59 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Gray Langur | *Semnopithecus entellus* | 166 | 372 | 5 | 538 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Rhesus macaque | *Macaca mulatta* | 1122 | 1377 | 2488 | 4987 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Monitor lizard | *Varanus bengalensis.* | 4 | 3 | 0 | 7 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Red Junglefowl | *Gallus gallus* | 55 | 90 | 28 | 173 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Kalij Phesant | *Lophura leucomelanos* | 0 | 39 | 4 | 43 |

| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Peafowl | *Pavo cristatus* | 208 | 227 | 3 | 438 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Indian Hare | *Lepus nigricollis* | 39 | 0 | 0 | 39 |


| Common Name | Scientific Name | Zone I | Zone II | Zone III | Total Captures |
|---|---|---|---|---|---|
| Rusty-spotted Cat | *Prionailurus rubiginosus* | 2 | 1 | 2 | 5 |

## ANNEXURE II

## Details of the 14 leopards camera trapped during the study

### L - 1

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD1 | L1 | 30.17448889 | 77.90086667 | 6/18/2020 | 9:30PM |

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# L - 2

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD1 | L2 | 30.17170278 | 77.89625833 | 4/30/2020 | 2:35AM |
| MORD2 | L2 | 30.17170278 | 77.89625833 | 5/30/2020 | 5:41AM |
| MORD3 | L2 | 30.17170278 | 77.89625833 | 05-05-2020 | 6:02PM |
| MORD4 | L2 | 30.17170278 | 77.89625833 | 5/20/2020 | 9:53PM |
| MORD5 | L2 | 30.17170278 | 77.89625833 | 5/22/2020 | 2:10AM |
| MORD9 | L2 | 30.17170278 | 77.89625833 | 5/22/2020 | 5:55AM |
| MORD22 | L2 | 30.17170278 | 77.89625833 | 5/21/2020 | 5:51AM |
| MORD24 | L2 | 30.17170278 | 77.89625833 | 6/17/2020 | 3:36AM |
| MORD25 | L2 | 30.17170278 | 77.89625833 | 4/28/2020 | 8:15PM |
| MORD30 | L2 | 30.17170278 | 77.89625833 | 06-08-2020 | 10:10PM |
| MORD35 | L2 | 30.17170278 | 77.89625833 | 5/20/2020 | 10:00PM |
| MORD37 | L2 | 30.17170278 | 77.89625833 | 5/14/2020 | 7:04PM |
| MORD38 | L2 | 30.17170278 | 77.89625833 | 5/23/2020 | 4:41AM |

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## L - 3

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD1 | L3 | 30.17340556 | 77.89871944 | 4/28/2020 | 12:08AM |
| MORD2 | L3 | 30.17340556 | 77.89871944 | 05-12-2020 | 2:42AM |
| MORD36 | L3 | 30.17340556 | 77.89871944 | 06-01-2020 | 3:28AM |

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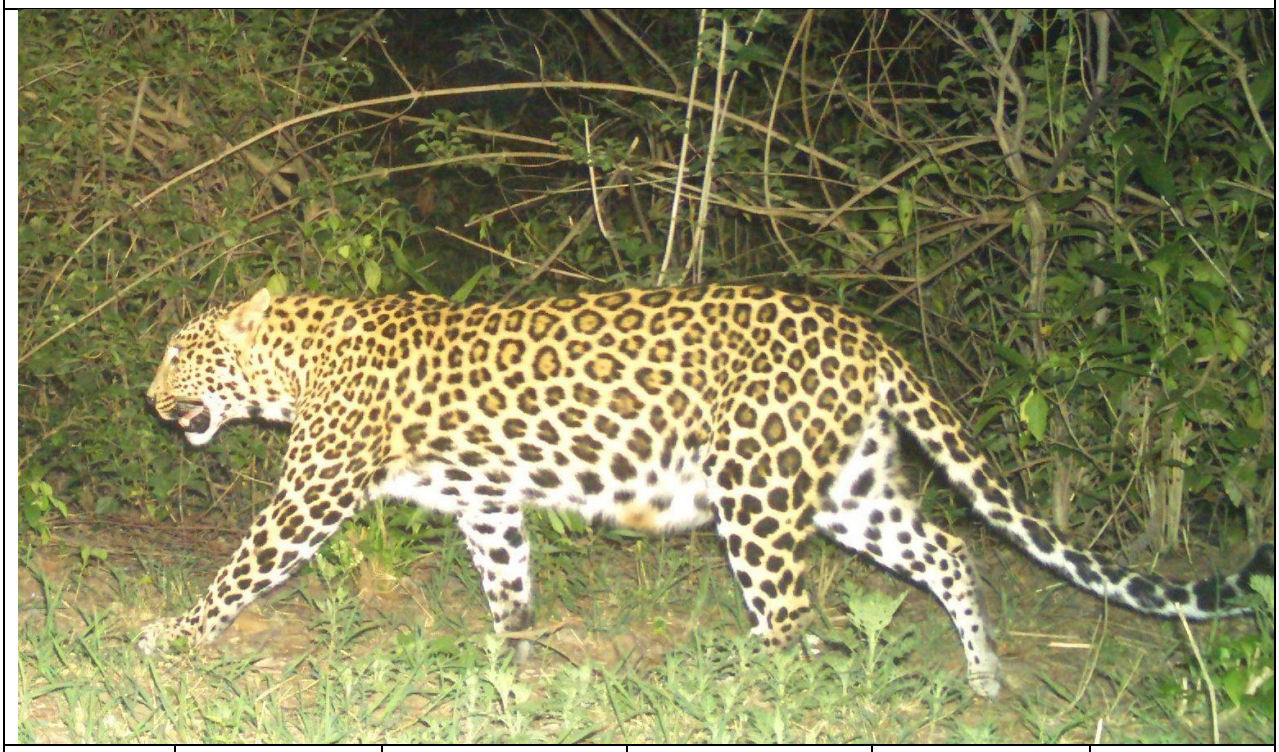
## L - 4



| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD4 | L4 | 30.17170278 | 77.89625833 | 6/29/2020 | 10:52PM |



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## L - 5

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD50 | L5 | 30.21900833 | 77.93861667 | 06-08-2020 | 9:16PM |
| MORD50 | L5 | 30.21900833 | 77.93861667 | 05-09-2020 | 8:32PM |
| MORD50 | L5 | 30.21900833 | 77.93861667 | 5?26/2020 | 12:09AM |
| MORD46 | L5 | 30.21900833 | 77.93861667 | 06-07-2020 | 10:23PM |



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## L - 6

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD49 | L6 | 30.21538889 | 77.93468333 | 07-04-2020 | 12:26AM |



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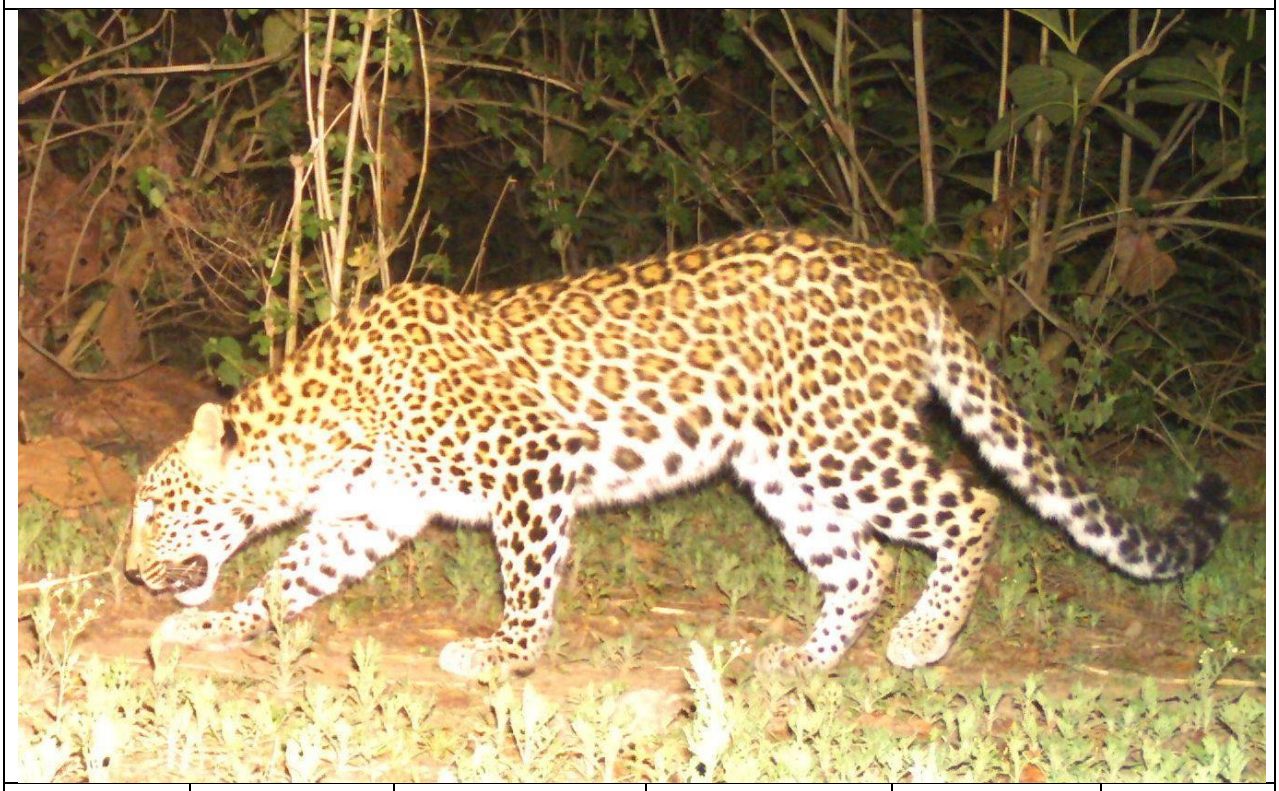
## L - 7



| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD52 | L7 | 30.17978889 | 77.91181111 | 6/17/2020 | 3:16AM |



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## L - 8

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD52 | L8 | 30.17978889 | 77.91181111 | 6/19/2020 | 4:06AM |



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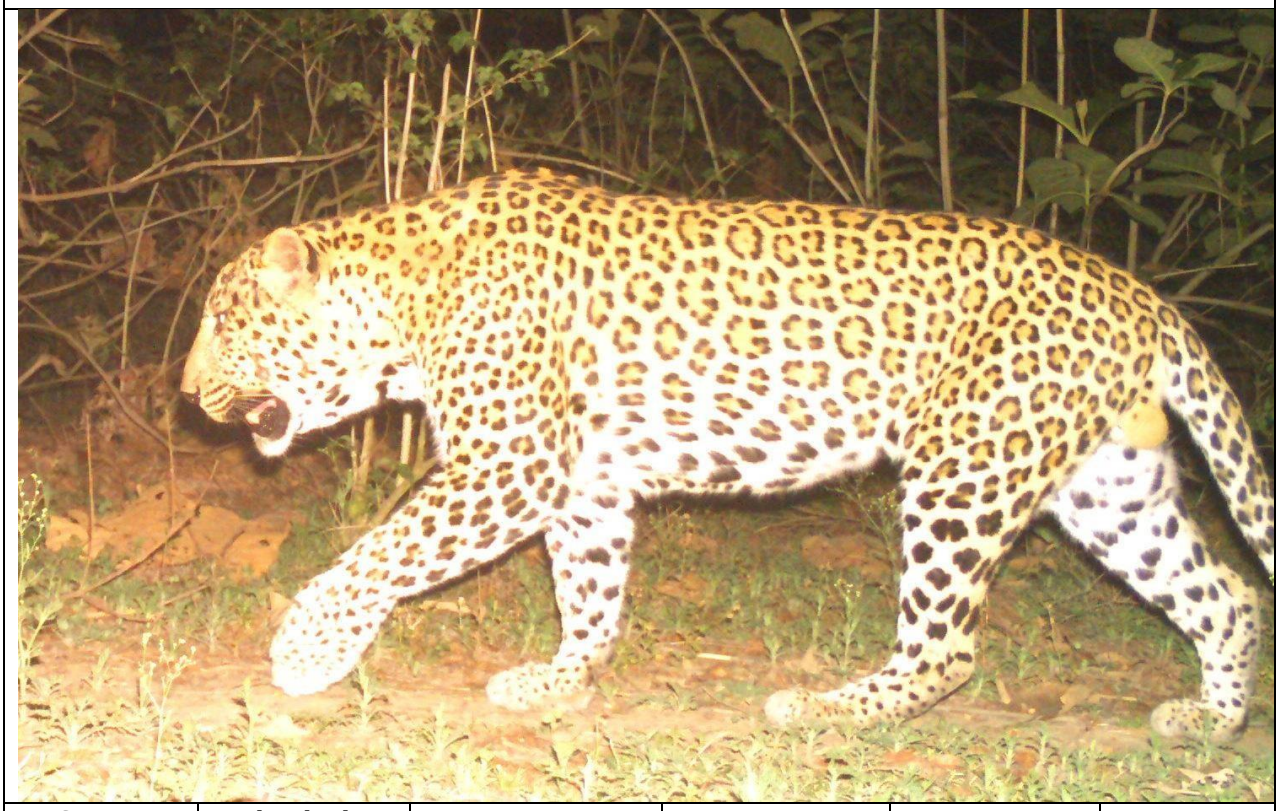
## L - 9



| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD52 | L9 | 30.17978889 | 77.91181111 | 06-09-2020 | 9:01PM |



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# L - 10

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD73 | L10 | 30.23913056 | 77.96895556 | 06-05-2020 | 3:01AM |
| MORD54 | L10 | 30.23913056 | 77.96895556 | 06?22/2020 | 4:29AM |



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## L - 11

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD67 | L11 | 30.22284722 | 77.93755278 | 6/19/2020 | 5:44AM |



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# L - 12

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD71 | L12 | 30.23715556 | 77.95914444 | 5/26/2020 | 5:07AM |
| MORD72 | L12 | 30.23715556 | 77.95914444 | 05-10-2020 | 8:41PM |

## L - 13

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD73 | L13 | 30.23913056 | 77.96895556 | 5/26/2020 | 8:47PM |
| MORD73 | L13 | 30.23913056 | 77.96895556 | 6/22/2020 | 1:57AM |



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## L - 14

| Cam ID | Individual ID | Lat DD | Long DD | Date | Time |
|---|---|---|---|---|---|
| MORD81 | L14 | 30.25815833 | 77.97690833 | 5/28/2020 | 3:05AM |



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