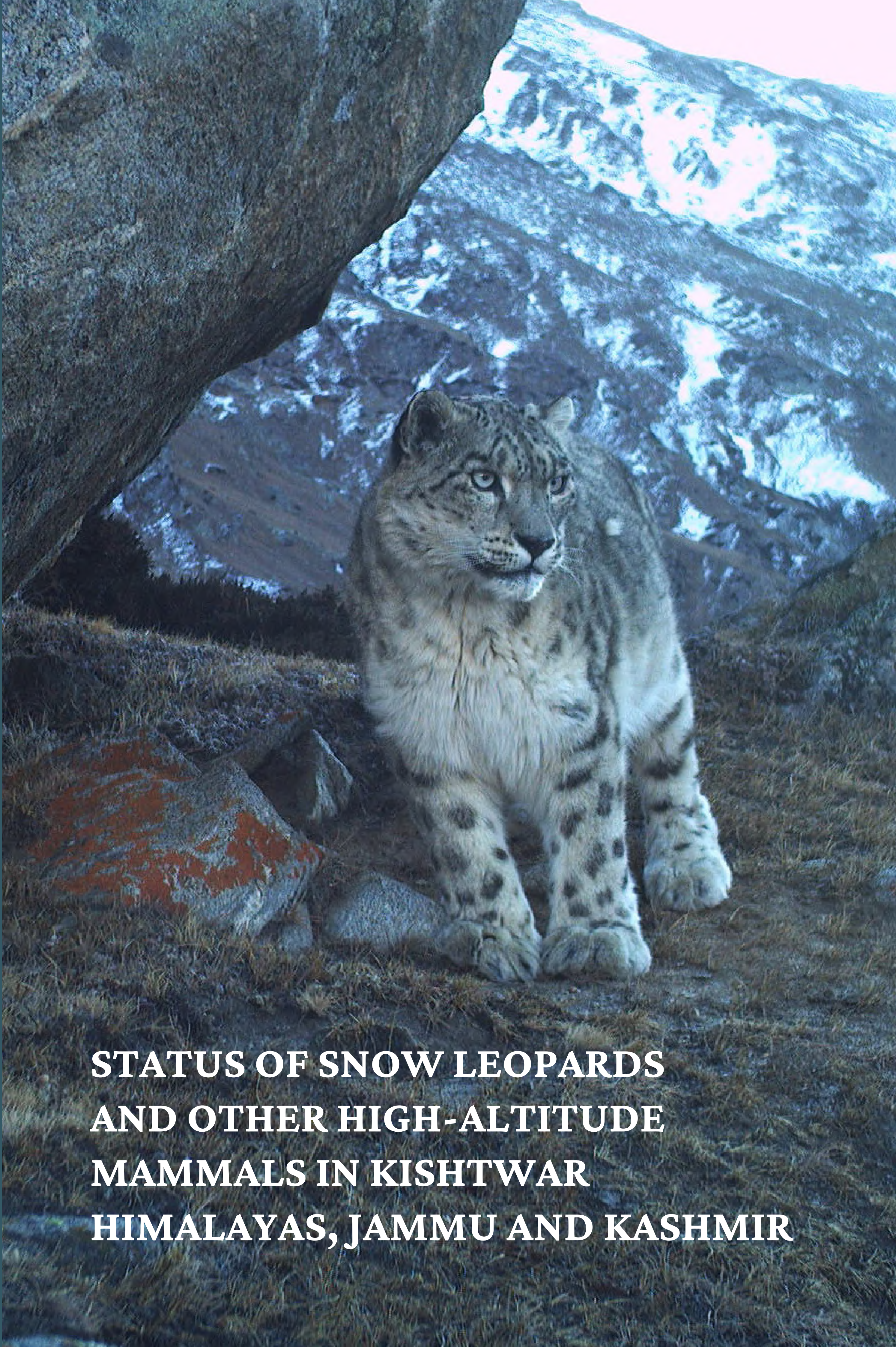

STATUS OF SNOW LEOPARDS AND OTHER HIGH-ALTITUDE MAMMALS IN KISHTWAR HIMALAYAS, JAMMU AND KASHMIR

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Report designed by Manini Bansal

STATUS OF SNOW LEOPARDS AND OTHER HIGH-ALTITUDE MAMMALS IN KISHTWAR HIMALAYAS, JAMMU AND KASHMIR

Contents

Executive Summary

The snow leopard is a key flagship and indicator species of the Indian Himalayas. Snow leopard range across vast areas, which are predominantly located outside formal protected areas. These areas are also home to local communities whose cultures, traditions, and livelihoods are deeply intertwined with these landscapes. Acknowledging the importance of these areas, the Government of India launched Project Snow Leopard in 2008 to safeguard and conserve India's unique natural heritage of high-altitude wildlife populations and their habitats by promoting conservation through participatory policies and actions. The pioneering SPAI project – Snow Leopard Population Assessment in India, which aligns with the global PAWS (Population Assessment of the World's Snow Leopards)- has been vital in understanding snow leopard populations across the Indian Himalayas.

Building on the groundbreaking collaborative work between the Nature Conservation Foundation (NCF) and the Department of Wildlife Protection, Jammu and Kashmir, in the understudied high-altitude regions of Jammu and Kashmir, our ongoing research initiative is now focused on the Kishtwar Himalayas; a critical stronghold for the endangered snow leopard. Through rigorous camera trap research, threat mapping and local capacity building, we are working to document and monitor these rare and endangered species, assess habitat health, and promote sustainable coexistence between wildlife and local communities.

Here we report the collaborative progress made by researchers of the Nature Conservation Foundation and the Jammu and Kashmir Wildlife Department in the high-altitude regions of the Kishtwar landscape, encompassing the Kishtwar High-Altitude National Park (KHANP), Warwan and Paddar Valley. Below are the key outcomes from this project:

1. We conducted systematic camera trapping across three sites in the Kishtwar landscape — KHANP, Paddar and Warwan. We detected a minimum of 12 individual snow leopards in 22 camera traps. Combining SECR estimates with raw counts from 2023, we estimate snow leopard numbers to be up to 20 adult individuals in our study area. We also, for the first time in J&K, estimated snow leopard densities for two regions (KHANP and Paddar) using the robust

spatially explicit capture-recapture. Densities in KHANP and Paddar were 0.49 snow leopards per 100 sq. km. (95% Confidence Intervals CI: 0.13-1.82 snow leopards per 100 sq. km.) and 0.36 snow leopards per 100 sq. km. (95% CI: 0.10-1.26 snow leopards per 100 sq. km.), respectively. During 2024, we only placed cameras in Kiyar valley of KHANP (13 cameras, 780 trap nights) and Paddar (38 cameras, 2,340 trap nights). A minimum of 13 and 8 independent snow leopard detections were obtained in Kiyar and Paddar, respectively. We estimated a density of 0.32 snow leopards per 100 sq. km. (95% CI: 0.066–1.63), with an abundance of 3 individuals (95% CI: 2–11) in Kiyar. In Paddar, we estimated a density of 0.35 snow leopards per 100 sq. km. (95% CI: 0.12–1.03), with an abundance of 5 individuals (95% CI: 4–13).

2. Our previous camera trapping efforts were conducted during the summer–autumn months. This left a temporal gap in our understanding of snow leopard space use across seasons. Driven by the need to better understand the seasonal presence and landscape use of snow leopards, we placed camera traps in the Zojila region of Kashmir and the Paddar region of Jammu between September 2024 and May 2025. These efforts successfully recorded snow leopards, which provides important evidence of their year-round occurrence in this landscape.

3. Besides snow leopards, we had detection of at least 16 mammal species across Warwan, KHANP and Paddar, including rare and threatened species. The camera traps recorded stone marten, snow leopard, asiatic ibex, red fox, porcupine, pika, musk deer, mountain weasel, himalayan stoat, long-tailed marmot, himalayan brown bear, common leopard, himalayan langur, rhesus macaque, leopard cat, jackal, and gray wolf. In KHANP (for data from 2024), the Himalayan brown bear (3.97), red fox (3.72), and Asiatic ibex (2.18) had the highest RAI. In Paddar (for data from 2024) red fox (RAI: 7.05), pika (4.83), and stone marten (3.59) were most abundant. Snow leopard RAI was 1.41 in KHANP and 0.43 in Paddar. Notably, the grey wolf and the common leopard were recorded in Paddar for the first time in this landscape context. In Warwan (for data from 2022) red fox (17.78) and Long-tailed Marmot (7.47) had the highest RAI.

4. Our snow leopard distribution model confirmed that the key snow leopard areas in Jammu and Kashmir were in the Kishtwar Himalayas (Warwan, Dacchan and Paddar). The adjoining regions of Thajawas-Zojila were also identified as areas with potentially high snow leopard occurrence.

5. Activity pattern analysis revealed strong nocturnal and crepuscular behavior among mammals, with site-specific differences. Paddar showed higher nocturnality than KHANP, which suggests the temporal adjustment of wildlife, perhaps to human presence.

6. Additionally, as a part of our local capacity building and conservation education, we conducted six workshops with a diverse group of participants: 480 school students, 500 undergraduate students, 30 postgraduate students, and 30 frontline staff from the Forest Department.

7. We also conducted a systematic threat assessment across the landscapes of Paddar, Dachhan, Marwah, and Warwan to develop a comprehensive understanding of land-use patterns and human-wildlife interactions. Livestock depredation and crop damage emerged as the most pressing challenges faced by local communities, threats that directly impact their primary sources of livelihood. Despite the scale of these issues, effective mitigation interventions are limited, which leaves communities to cope with losses on their own, often leading to negative perceptions of wildlife.

Introduction

Snow Leopard (*Panthera uncia*) is a flagship species for the conservation of the High Himalayas. The snow leopard faces many threats throughout its distribution range. It is threatened by large-scale developmental projects such as mining and large infrastructure; rising livestock populations that can out-compete the wild herbivore prey of the snow leopard; increasing conflict with the herding community, leading to their persecution; and an increase in poaching for snow leopard body parts (Mishra et al., 2022). In India, snow leopards are found in the states of Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh, while also being found in the Union Territories of Jammu and Kashmir and Ladakh.

Across India, much of the research on snow leopards has focused on the trans-Himalayan region, which is the rain-shadow region of the Himalayas along the border with the Tibetan plateau. The Greater Himalaya, within which the union territory of Jammu and Kashmir lies, harbours potential snow leopard habitat but has seen limited surveys and research on snow leopards (Suryawanshi et al., 2019). Snow leopard habitats in the Greater Himalayas tend to be in remote locations and lack access and research infrastructure. The snow leopard habitat of Jammu and Kashmir is a source of local and regional ecosystem services such as freshwater used by millions of people living downstream and, in the plains, and sustains unique high-altitude cultures (Murali et al. 2017).

This study, as part of our long-term snow leopard research in Jammu and Kashmir, aimed to conduct a robust monitoring of snow leopard populations across the Kishtwar Himalayan landscapes, including KHANP, Warwan, and Paddar. Additionally, the relative abundance of other high-altitude mammalian species was also recorded across these landscapes. Robust population estimates over an extended period aid in determining population trends (Mihoub et al. 2017). Therefore, comprehensive population monitoring is critical in framing conservation objectives. Moreover, an understanding of the population dynamics of prey species and sympatric species can further complement conservation initiatives (Bull et al. 2014).

Methods and Study area

Cameras were placed in Warwan between September and October 2022. A total of 25 cameras were placed here for 45 days, resulting in 1125 camera trap nights. In KHANP (Kiyar, Nanth and Kibber), 44 cameras were placed in total between April

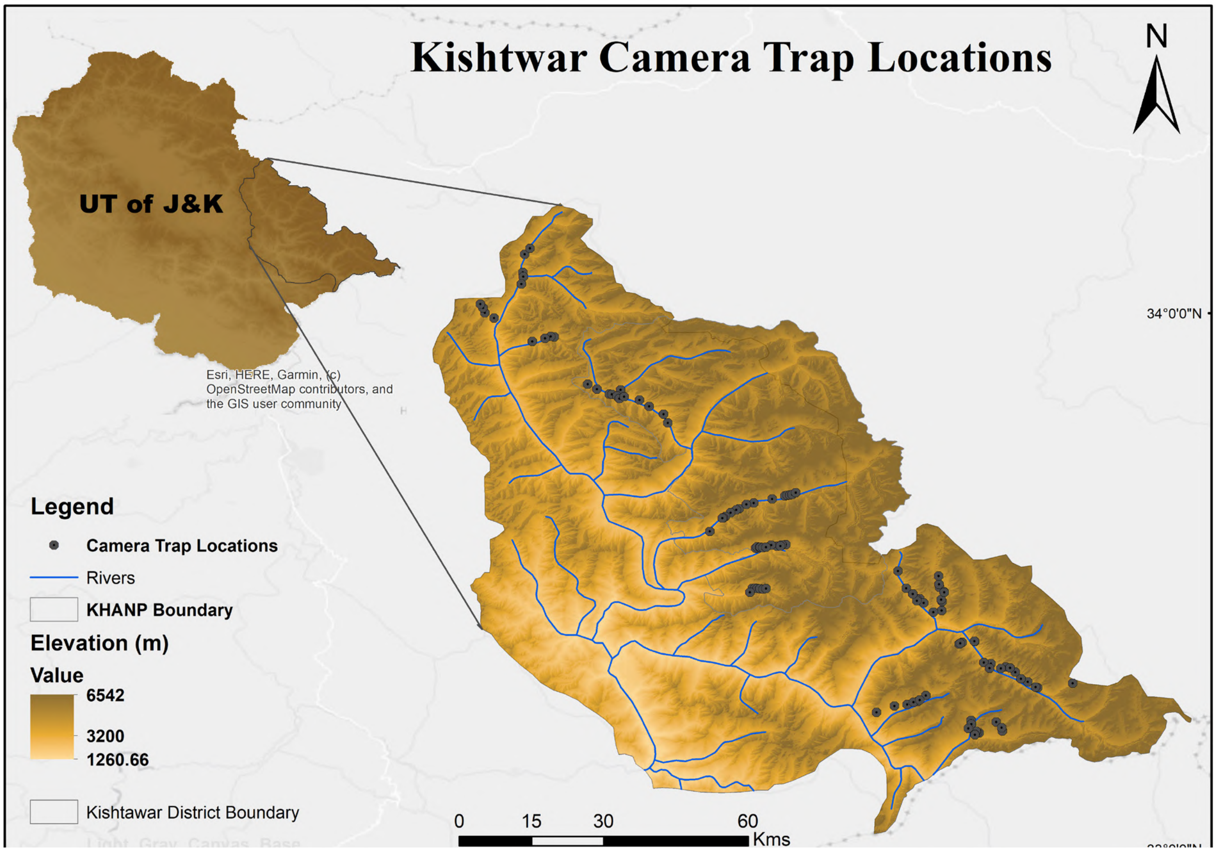


Figure 1. *Map of the study area*

and June 2023, also for 45 days, resulting in 1980 camera trap nights. In Paddar, a total of 41 cameras were placed between October and November 2023, also for 45 days, resulting in 1845 camera trap nights. In 2024, we surveyed two sites-Kiyar & Paddar, where we placed cameras for a period of ~60 days to ensure a closed population (both 45 days and 60 days are considered long enough to meet the closure assumption for snow leopards). In 2024 in total, 51 cameras were placed across a total of ~3060 camera trap days (Figure 1 and Table 1 below).

We also generated Figure 1b, which is an updated snow leopard distribution model in Jammu and Kashmir using an ensemble modelling approach. As seen from the model output, key snow leopard areas seem to be those adjacent to the Zanskar and Drass region of Ladakh, including Tulail, Thajawas-Zojila, Kishtwar High Altitude National Park and Paddar.

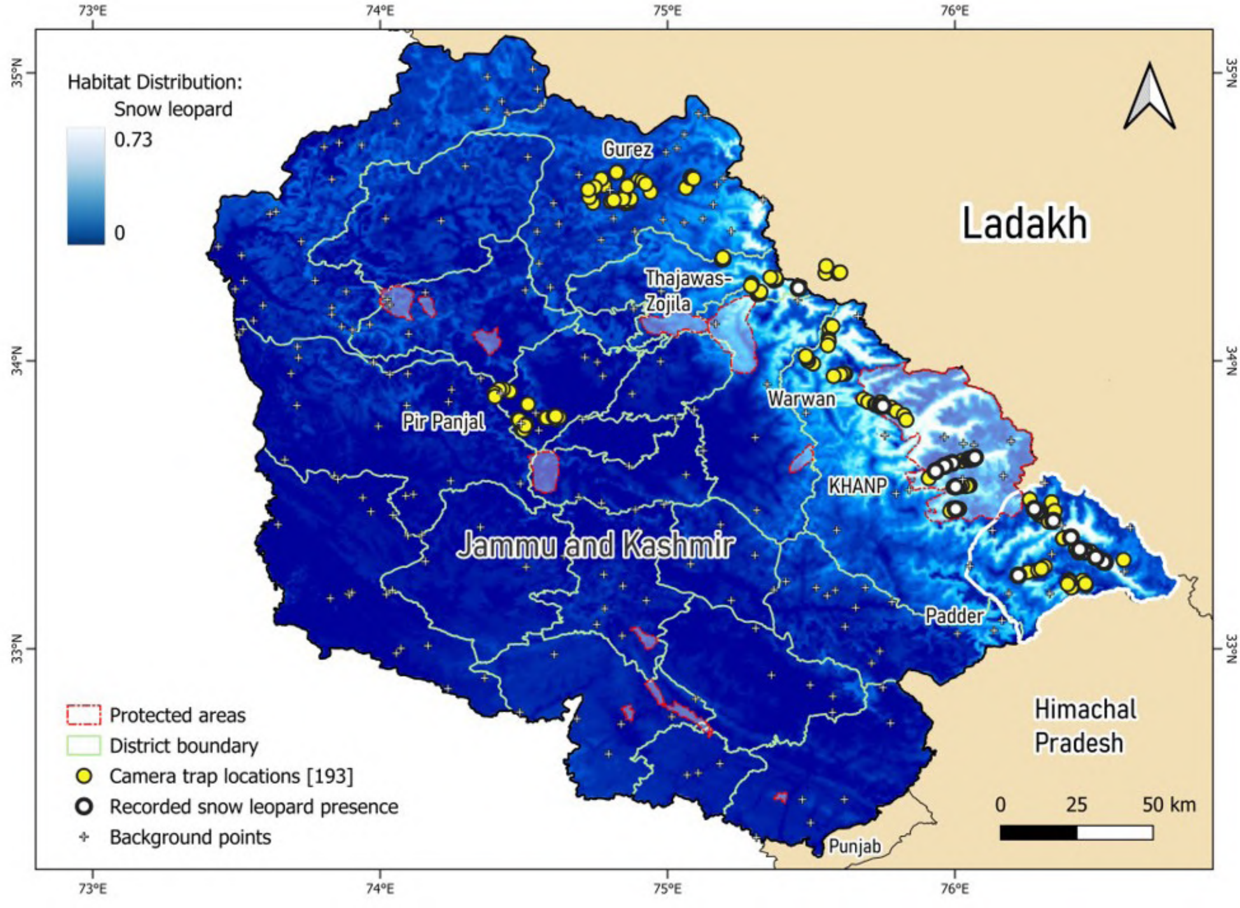


Figure 1b. *An updated species distribution modelling map of snow leopard distribution in Jammu and Kashmir.*

Table 1. *Camera trap effort information across Jammu and Kashmir.*
Note: In this report, we only present results from the landscapes in the Kishtwar Himalayas and Thajawas-Zojila from 2024-25. [Highlighted].

Landscape	Year	Period of survey	No. of cameras placed	Total camera trap effort
Paddar	2024-25	Nov '24 -May '25	15	2520
Thajawas-Zojila	2024-25	Nov '24 -May '25	2	360
Kiyar	2024	Sept-Nov	13	780
Paddar	2024	Sept-Nov	38	2,340
KHANP	2023	April-June	44	1980
Paddar	2023	Oct-Nov	41	1845
Gurez	2022	April-June	30	1350
Thajawas-Zojila	2022	Sept-Oct.	26	1170
Warwan	2022	Sept. Oct	25	1125

We considered the design requirements of spatially explicit capture-recapture (SECR), particularly placing adequate cameras to enable multiple captures of individual snow leopards at different locations. Camera trap locations were chosen to fit the SECR design based on our understanding from the previous snow leopard camera trapping. Camera traps were installed based on the prevalence of snow leopard signs, which included hair, scat, scrape or urine spray marks and any other suitable microhabitats (e.g. overhanging boulders in cliffs) to maximise detection at each location.

Due to the rugged landscape, instead of a uniform design, we deployed camera traps in a clustered manner. Nevertheless, where possible, we tried to maintain 2 or more cameras per 4 x 4 grid (Suryawanshi et al. 2021). Being smaller than a snow leopard's home range, this study design allows for an individual to be captured across multiple traps, which is key to estimating the scale of movement in a spatially explicit analysis. We intentionally did not deploy cameras below 3,000 m, because most of these areas seemed below the elevation limits of snow leopard habitats (Suryawanshi et al, 2021).

Camera trap field experts placing camera traps at a strategic location

Upon retrieval of the cameras, photos were tagged at the species level using digiKam software (https://www.digikam.org/) and the tags were read out using the camtrapR package (Niedballa et al., 2016). A major source of bias in population assessments of snow leopards is errors in individual identification, and thus, to reduce bias, we used a two-step process to classify images and identify individual snow leopards as recommended by Suryawanshi et al (2021). Step one is the identification phase, and step two is the review phase. In step one, two researchers catalogued all photos of snow leopards from each site independently. Different individuals were identified using unique rosette patterns on different body parts. Following this, in step two, a third researcher compared and reviewed all the individual identifications and resolved any disagreements between the two. All reviewers were trained using the CamTraining application (camtraining.globalsnowleopard.org).

A maximum-likelihood-based Spatially Explicit Capture-Recapture (SECR) model was used to estimate the population densities of snow leopards (Efford and Fewster 2013). SECR models explicitly use the spatial information of detection location at the camera traps, accounting for the heterogeneity in captures due to animal activity centre location. Heterogeneity may arise because the probability of capture in a specific camera trap depends on its location relative to the animal's activity centre, based on the assumption that the detection probability decreases as the distance from a detector to an individual's activity centre increases (Efford et al., 2009). A habitat mask was created using a buffer width of 14 km around the traps and a spacing of 1500 m between mask points to create a state space. However, within this 14 Km buffer, the areas falling below the tree line were removed using a shapefile mask. Density was estimated using a single-session SECR model (D ~ 1, g0 ~ 1, sigma ~ 1) and a half-normal detection function was used to model detection probability. Sigma can be interpreted as an index of home range size, while g0 is an indication of detectability. The SECR analysis was carried out using the package secr in R (version 4.4.2).

For other non-volant mammals (excluding small rodents and Insectivora), we calculated relative abundance indices (RAIs) as

$$RAI = \frac{A}{N} \times 100$$

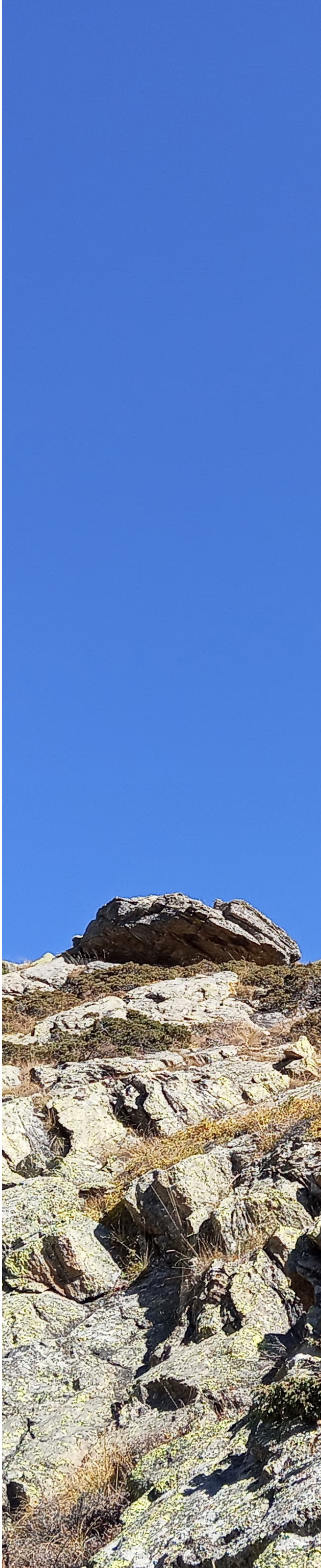
Here, A is the total number of independent encounters of a species by all cameras, and N is the total number of camera trap days, which is the total number of cameras multiplied by ~60 or 45 (as that is the survey period for the given site) (Jenks et al. 2011). We considered all consecutive pictures that show different species as independent events. Pictures of the same species taken more than 30 minutes apart were also taken as independent events. While there is debate about how accurately RAIs reflect species abundance, they are still widely used to compare species capture frequency at different sites.

Activity pattern analysis

This was done solely as an exploratory analysis using the data obtained from 2024 as that is when the surveys in Kiyar and Paddar occurred during the same season. To characterize and compare mammalian activity patterns between Kiyar and Paddar, we converted event times into radians (0-2π scale) and applied circular kernel density estimation using the overlap package in R (v4.4.2). We conducted three levels of analysis: (1) site-level comparisons combining all mammal species, (2) species-specific comparisons between sites, and (3) pairwise overlap quantification using the Δ_4 coefficient (range: 0 = no overlap to 1 = complete overlap).

For each comparison, we calculated 95% confidence intervals through a smoothed bootstrap procedure with 1,000 resamples. We used the camtrapR package to process raw camera trap metadata and the activity package for temporal data conversion. Activity curves were generated using densityplot and comparative visualisations with the overlapplot functions. All analyses incorporated a minimum sample threshold of ≥5 independent detections per species per site to ensure robust density estimation.

We followed established protocols for circular statistics in temporal ecology, implementing the Dhat4 estimator for overlap calculation and bootstrap confidence intervals (Meredith & Ridout, 2021).



KHANP

Field team looking for a location to place cameras in the Kiyar Valley of KHANP

The camera trapping effort at Kiyar in 2024 comprised 780 trap nights. 13 independent snow leopard detections were recorded across 13 camera locations. A density of 0.32 snow leopards per 100 sq. km. (Confidence Interval, 95% CI: 0.066-1.63 snow leopards per 100 sq km.) was estimated using SECR analysis (Table 2a). This equates to an abundance of three individuals (95% CI: 2-11) in the study area. The detection probability of snow leopards at the activity centers (g0) was estimated to be 0.024 (95% CI: 0.01-0.05) while the sigma was estimated to be 4831 m (95% CI: 2797-8343 m). The lower estimated abundance in 2024 compared to 2023 (Table 2b) could be attributed to a comparatively smaller geographical area being sampled during the year 2024. Just looking at Kiyar, data for snow leopards was similar between 2023 and 2024.

In 2023, a total of 16 mammalian species were recorded across the KHANP landscape (Table 3b). The RAI of each species is displayed in Figure 2a, with Table 3b summarizing key camera trapping statistics. Long-tailed marmots had the highest RAI of 21.67, followed by pikas with 18.79. However, in 2024, a total of 11 mammalian species (Figure

3) were recorded across the Kiyar Valley. Noteworthy to mention, we didn't sample Kibber and Nath Valley in 2024. The RAI of each species is displayed in Figure 2b, with Table 3a summarising key camera trapping statistics. The Himalayan brown bear had the highest RAI of 3.97, followed by the red fox with 3.72. The highest number of detections, among carnivores, across the Kiyar, KHANP landscape was recorded for red fox, followed by snow leopard. Overall, the highest number of detections was recorded for Asiatic Ibex and Himalayan brown bear. Meanwhile, with an RAI of 3.72 and 1.41, respectively, red foxes and snow leopards also had the highest RAI amongst carnivores. Furthermore, red fox and snow leopard were detected at the highest number of locations (n=8). Snow leopards had an RAI of 1.41 while their main prey species, Asiatic ibex, had an RAI of 2.18.

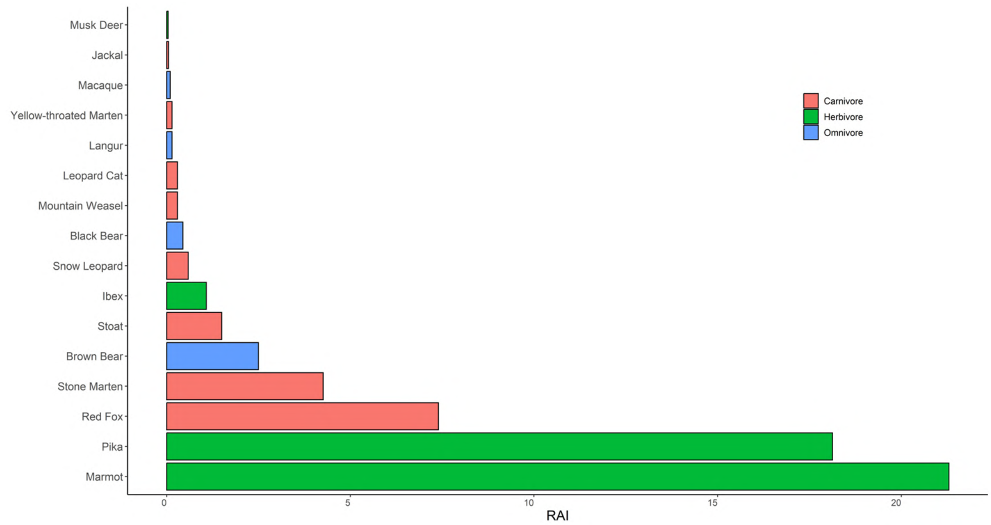


Figure 2a. *Relative abundance index (RAI) of mammals in KHANP (2023).*

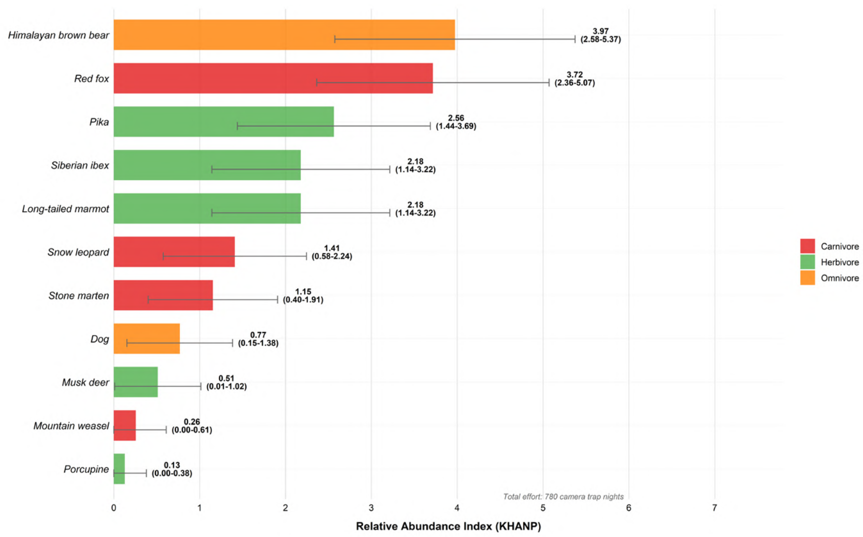


Figure 2b. *Relative abundance index (RAI) of mammals in Kiyar (2024).*

Table 2a. *Table displaying SECR results for Kiyar, KHANP (2024).*

Parameter	Estimate	Standard Error	Lower Confidence Interval	Upper Confidence Interval
density (individuals per 100 km^2)	0.328	0.322	0.066	1.63
g0	0.024	0.0002	0.011	0.052
sigma (m)	4831	1370	2797	8343
abundance	3	1.6	2	11

Table 2b. *SECR estimates for snow leopards in Kishtwar High Altitude National Park (2023)*

Parameter	Estimate	Standard Error	Lower Confidence Interval	Upper Confidence Interval
density (individuals per 100 km^2)	0.49	0.37	0.13	1.82
g0	0.018	0.0091	0.0070	0.048
sigma (m)	4138	1533	2049	8355
abundance	4	0.8	4	9

Table 3a. *Table displaying key camera trapping statistics from Kiyar, KHANP (2024).*

Common Name	Scientific Name	No. of Detections	No. of Locations Detected at	Relative Abundance Index
Herbivore				
Asiatic Ibex	*Capra sibirica*	17	6	2.18
Long-tailed Mar-mot	*Marmota caudata*	17	4	2.18
Musk Deer	*Moschus sp.*	4	3	0.51
Pika	*Ochotona sp.*	20	3	2.56
Porcupine	*Hystrix indica*	1	1	0.13
Omnivore				
Himalayan Brown Bear	*Ursus arctos isabellinus*	31	7	3.97
Dog	*Canis lupus famil-iaris*	6	2	0.77
Carnivore				
Mountain Weasel	*Mustela altaica*	2	1	0.26
Snow Leopard	*Panthera uncia*	11	8	1.41
Stone Marten	*Martes foina*	8	4	1.51
Red fox	*Vulpes vulpes*	29	8	3.72

__Table 3b.__ Table displaying key camera trapping statistics from KHANP landscape (2023).

Common Name	Scientific Name	No. of Detections	No. of Locations Detected at	Relative Abundance Index
Herbivore				
Asiatic Ibex	*Capra sibirica*	22	4	1.11
Long-tailed Marmot	*Marmota caudata*	429	18	21.67
Musk Deer	*Moschus cupreus*	1	1	0.05
Pika	*Ochotona sp.*	372	17	18.79
Omnivore				
Asiatic Black Bear	*Ursus thibetanus*	9	4	0.45
Himalayan Brown Bear	*Ursus arctos isabellinus*	51	14	2.58
Grey Langur	*Semnopithecus schistaceus*	3	2	0.15
Rhesus Macaque	*Macaca mulatta*	2	1	0.10
Carnivore				
Golden Jackal	*Canis aureus*	1	1	0.05
Himalayan Stoat	*Mustela erminea*	31	10	1.57
Leopard Cat	*Prionailurus bengalensis*	6	3	0.30
Mountain Weasel	*Mustela altaica*	9	3	0.45
Snow Leopard	*Panthera uncia*	12	8	0.61
Stone Marten	*Martes foina*	87	21	4.39
Yellow-Throated Marten	*Martes flavigula*	3	2	0.15
Red fox	*Vulpes vulpes*	151	26	7.62

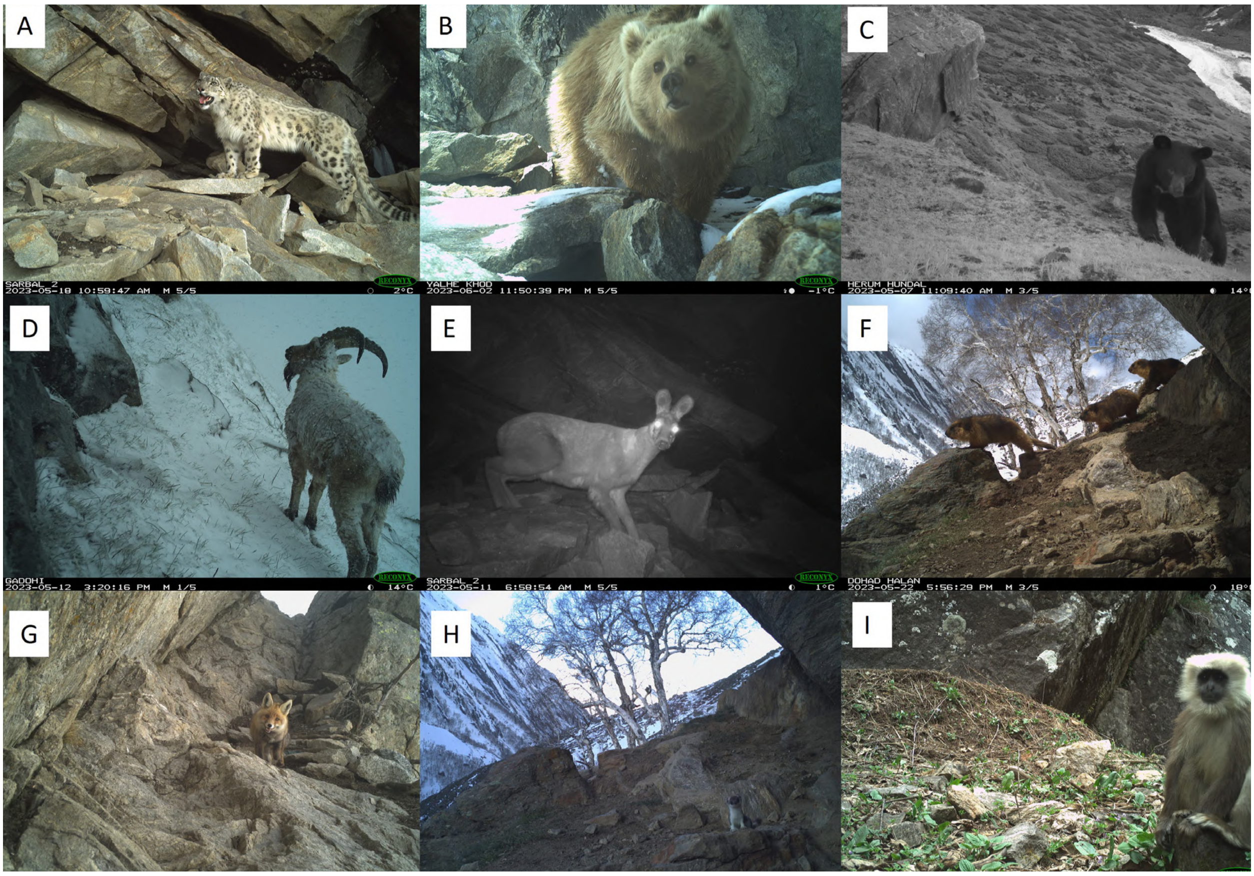


Figure 3A. *A panel showcasing select images from camera trapping in KHANP (2023). A: Snow Leopard, B: Himalayan Brown Bear, C: Asiatic Black Bear, D: Asiatic Ibex, E: Kashmir Musk Deer, F: Long-tailed Marmot, G: Red Fox, H: Himalayan Stoat, I: Kashmir Gray Langur*

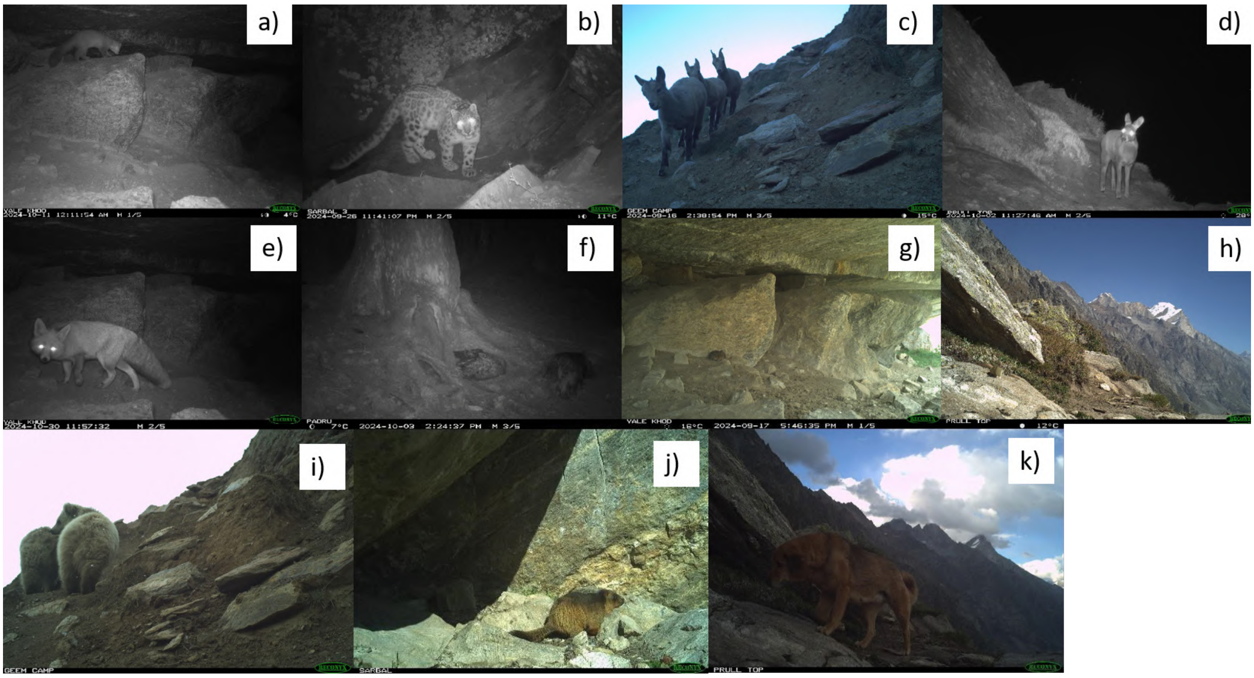


Figure 3B. *A panel showcasing select images from camera trapping in KHANP (2024). a) Stone marten b) Snow leopard, c) Asiatic ibex, d) Musk deer e) Red fox, f) Porcupine, g) Pika h) Mountain weasel, i) Himalayan brown bear j) Long-tailed marmot, and k) Dog.*

Paddar

Team exiting Barnaz valley after completing camera installation

The camera trapping effort in 2023 for Paddar consisted of 1845 trap nights with 10 snow leopard detections across 8 camera locations (Figure 5A). The SECR analysis (Table 4a) estimated a density of 0.35 snow leopards per 100 sq. km. (95% CI: 0.12-1.03 snow leopards per 100 sq. km.). This corresponds to an abundance of five individuals (95% CI: 4-13). The detection probability at the activity centres (g0) was estimated to be 0.024 (95% CI: 0.011-0.052), whereas the sigma was estimated to be 4831m (95% CI: 2797-8343m). Interestingly, the estimated abundance in Paddar was the same for 2023 & 2024 (Table 4a-b), with the value of sigma higher in 2024.

Meanwhile, a total of 11 species of mammals (Figure 5B) were recorded across Paddar in 2024. Figure 4b displays the cumulative Relative Abundance Index (RAI) for these mammals across all camera traps in Paddar, with Table 5 displaying key camera statistics. Red fox had the highest RAI (7.05), followed by Pika (4.83). Additionally, the red fox had the highest number of detections and was detected at the highest number of locations. While the snow leopard had an RAI of 0.43, its primary prey, the Asiatic Ibex, had a low RAI (0.30). Meanwhile, the only other detected ungulate species, musk deer, had a RAI of 0.81. This year, we also recorded a grey wolf from Paddar, having an estimated RAI of 0.13 (Figure 4b). Interestingly, the top three species with the highest recorded RAI in Paddar during 2023 and 2024 were the red fox, stone marten, and pika.

Table 4a. *SECR estimates for snow leopards in Paddar (2023)*

Parameter	Estimate	Standard Error	Lower Confidence Interval	Upper Confidence Interval
density (individuals per 100 km^2)	0.35	0.209	0.12	1.03
g0	0.024	0.0073	0.011	0.052
sigma (m)	4831	1370	2797	8343
abundance	5	1.6	4	13

Table 4b. *SECR estimates for snow leopards in Paddar (2024)*

Parameter	Estimate	Standard Error	Lower Confidence Interval	Upper Confidence Interval
density (individuals per 100 km^2)	0.36	0.27	0.10	1.26
g0	0.016	0.0073	0.0064	0.039
sigma (m)	5611	2087	2770	11365
abundance	5	1.3	5	14

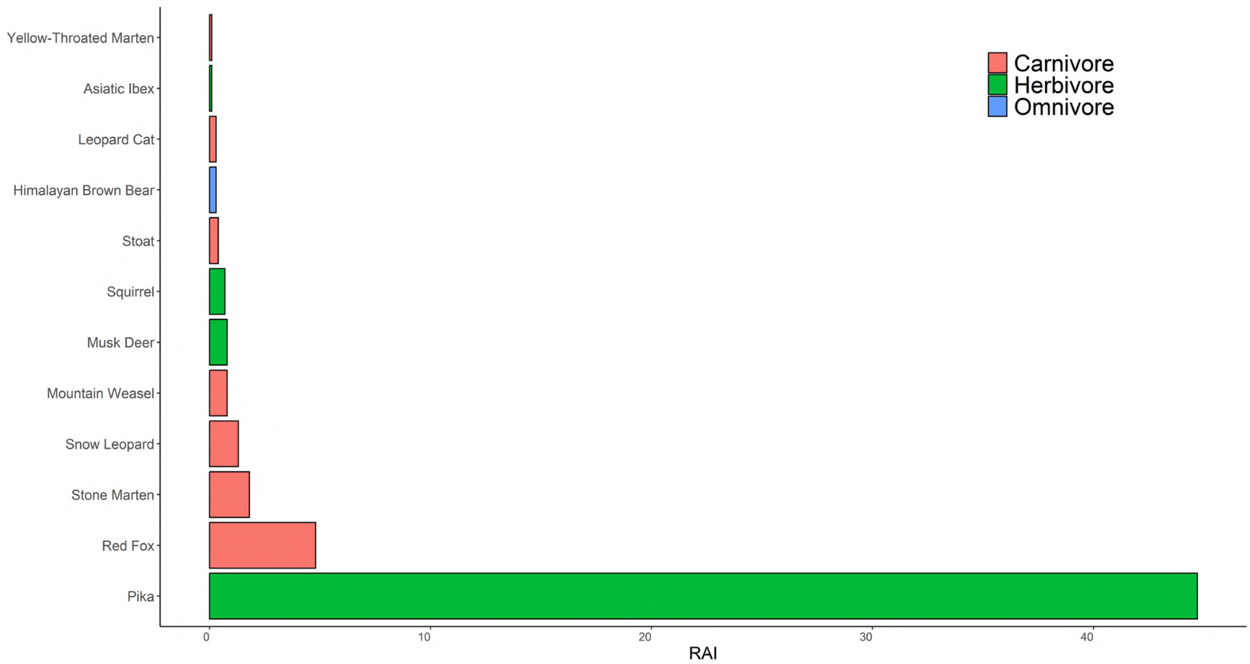


Figure 4a. *Relative abundance index (RAI) of mammals in Paddar (2023).*

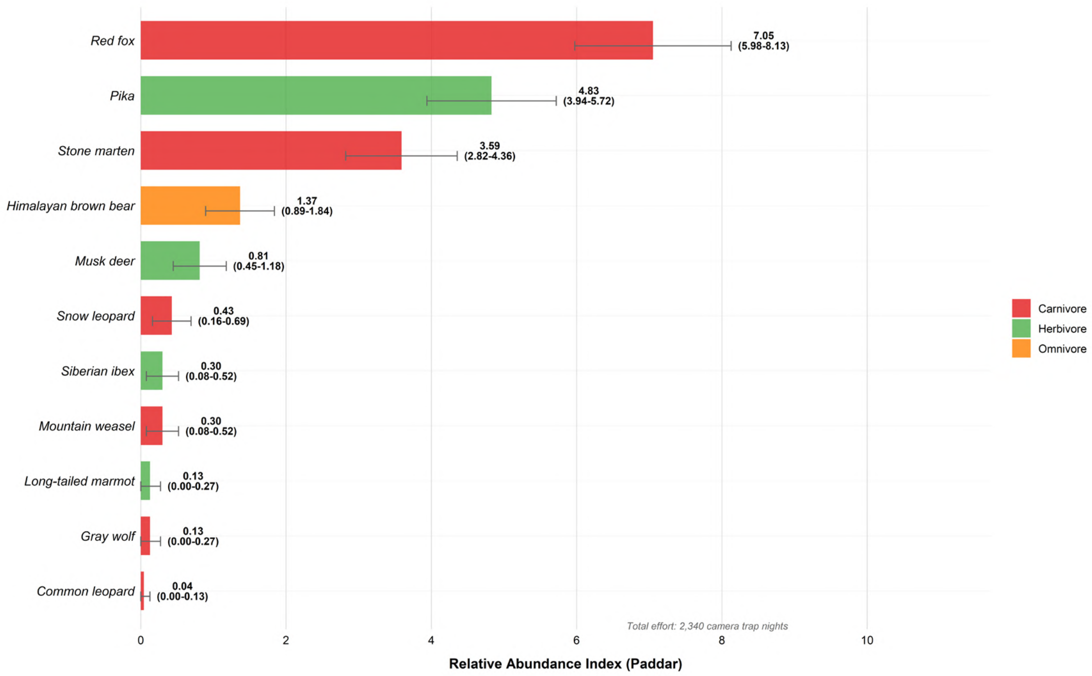


Figure 4b. *Relative abundance index (RAI) of mammals in Paddar (2024).*

Table 5a. Table displaying key camera trapping statistics from Paddar in 2024

Common Name	Scientific Name	No. of Detections	No. of Locations Detected at	Relative Abundance Index
Herbivore				
Long-tailed Marmot	*Marmota caudata*	3	2	0.13
Musk Deer	*Moschus cupreus*	19	7	0.81
Pika	*Ochotona sp.*	113	13	4.83
Asiatic Ibex	*Capra sibirica*	7	3	0.30
Omnivore				
Himalayan Brown Bear	*Ursus arctos isa-bellinus*	32	8	1.37
Carnivore				
Mountain Weasel	*Mustela altaica*	7	6	0.30
Common leopard	*Pathera Pardus*	1	1	0.04
Snow Leop-ard	*Panthera uncia*	10	8	0.43
Stone Marten	*Martes foina*	84	16	3.59
Red fox	*Vulpes vulpes*	165	24	7.05
Gray wolf	*Canis lupus*	3	2	0.13

Table 5b. *Table displaying key camera trapping statistics from Paddar in 2023*

Common Name	Scientific Name	No. of Detections	No. of Locations Detected at	Relative Abundance Index
Herbivore				
Asiatic Ibex	*Capra sibirica*	1	1	0.08
Wooly Flying Squirrel	*Eupetaurus cinereus*	9	1	0.69
Musk Deer	*Moschus cupreus*	10	3	0.78
Pika	*Ochotona sp.*	584	14	44.75
Omnivore				
Himalayan Brown Bear	*Ursus arctos isabellinus*	4	1	0.31
Carnivore				
Leopard Cat	*Prionailurus bengalensis*	4	2	0.31
Himalayan Stoat	*Mustela erminea*	5	4	0.38
Mountain Weasel	*Mustela altaica*	10	5	0.77
Stone Marten	*Martes foina*	23	12	1.76
Snow Leopard	*Panthera uncia*	17	11	1.30
Red fox	*Vulpes vulpes*	62	20	4.75

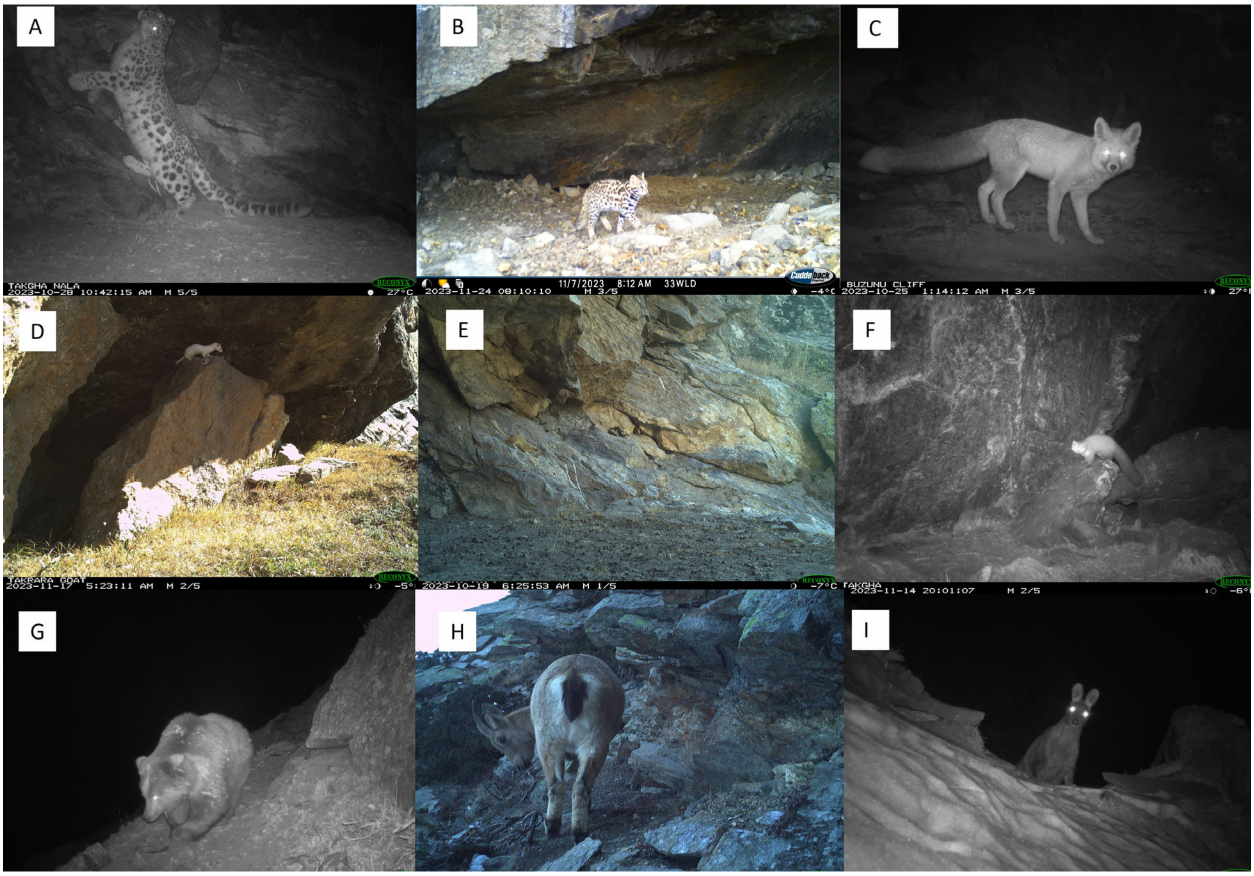


Figure 5A. *A panel showcasing select images from camera trapping in Paddar (2023). A: Snow Leopard, B: Leopard Cat, C: Red Fox, D: Himalayan Stoat, E: Mountain Weasel, F: Stone Marten, G: Himalayan Brown Bear, H: Asiatic Ibex, I: Kashmir Musk Deer.*

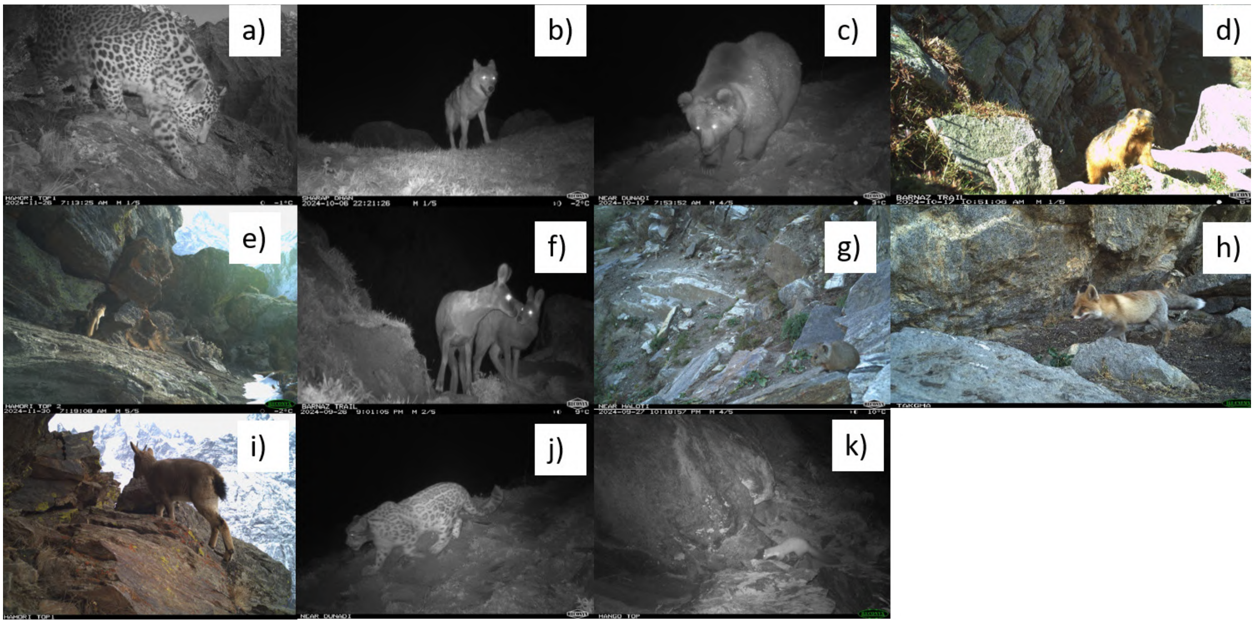


Figure 5B. *A panel showcasing select images from camera trapping in Paddar (2024) a) Common leopard, b) gray wolf, c) Himalayan brown bear, d) Long-tailed marmot, e) Mountain weasel, f) Musk deer, g) Pika, h) Red fox, i) Asiatic Ibex, j) Snow leopard, and k) Stone marten.*

During the winter of 2024–2025, camera trapping conducted in the Zojila region of Kashmir and the Paddar region of Jammu recorded the presence of snow leopards (Figure 5B and Figure 5C). In Paddar, both snow leopards and common leopards (Figure 5C. a&d) were detected at the same camera trap locations.

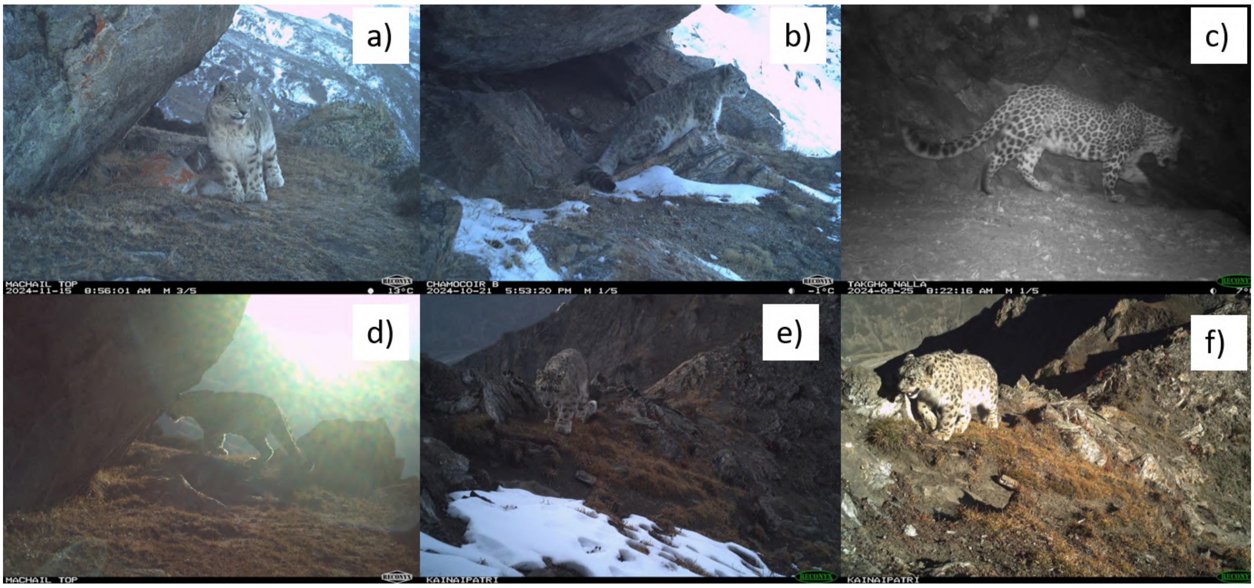


Figure 5C. *A panel showcasing select images from camera trapping in Paddar and Zojila (2024-25) a & b) Snow leopard c & d) common leopard in Paddar, Jammu division. e & f) Snow leopard detections in Zojila, Kashmir division.*

Warwan

Field team walking across the Tramsar pass in Warwan

The camera trapping effort at Warwan covered 1,125 trap nights across 25 locations. In Warwan, snow leopards had the lowest RAI of 0.09 with only a single detection. Identically, yellow-throated marten, musk deer and Kashmir flying squirrels were also detected only once and had a RAI of 0.09. Red fox not only had the highest RAI (17.78) but was also detected at the highest number of locations (20). These results have been summarised in Table 6 and Figures 6 and 7 .

Table 6. Table displaying key camera trapping statistics from Warwan (2023)

Common Name	Scientific Name	No. of Detections	No. of Locations Detected at	Relative Abundance Index
Herbivore				
Asiatic Ibex	*Capra sibirica*	19	2	1.69
Long-tailed Marmot	*Marmota caudata*	84	9	7.47
Musk Deer	*Moschus sp.*	1	1	0.09
Pika	*Ochotona sp.*	18	5	1.60
Kashmir Flying Squirrel	*Eoglaucomys fimbriatus*	1	1	0.09
Omnivore				
Himalayan Brown Bear	*Ursus arctos isabellinus*	13	7	1.16
Carnivore				
Himalayan Stoat	*Mustela erminea*	1	1	0.09
Himalayan Wolf	*Canis lupus*	21	6	1.87
Snow Leopard	*Panthera uncia*	1	1	0.09
Stone Marten	*Martes foina*	25	11	2.22
Yellow-Throated Marten	*Martes flavigula*	1	1	0.09
Red fox	*Vulpes vulpes*	200	20	17.78

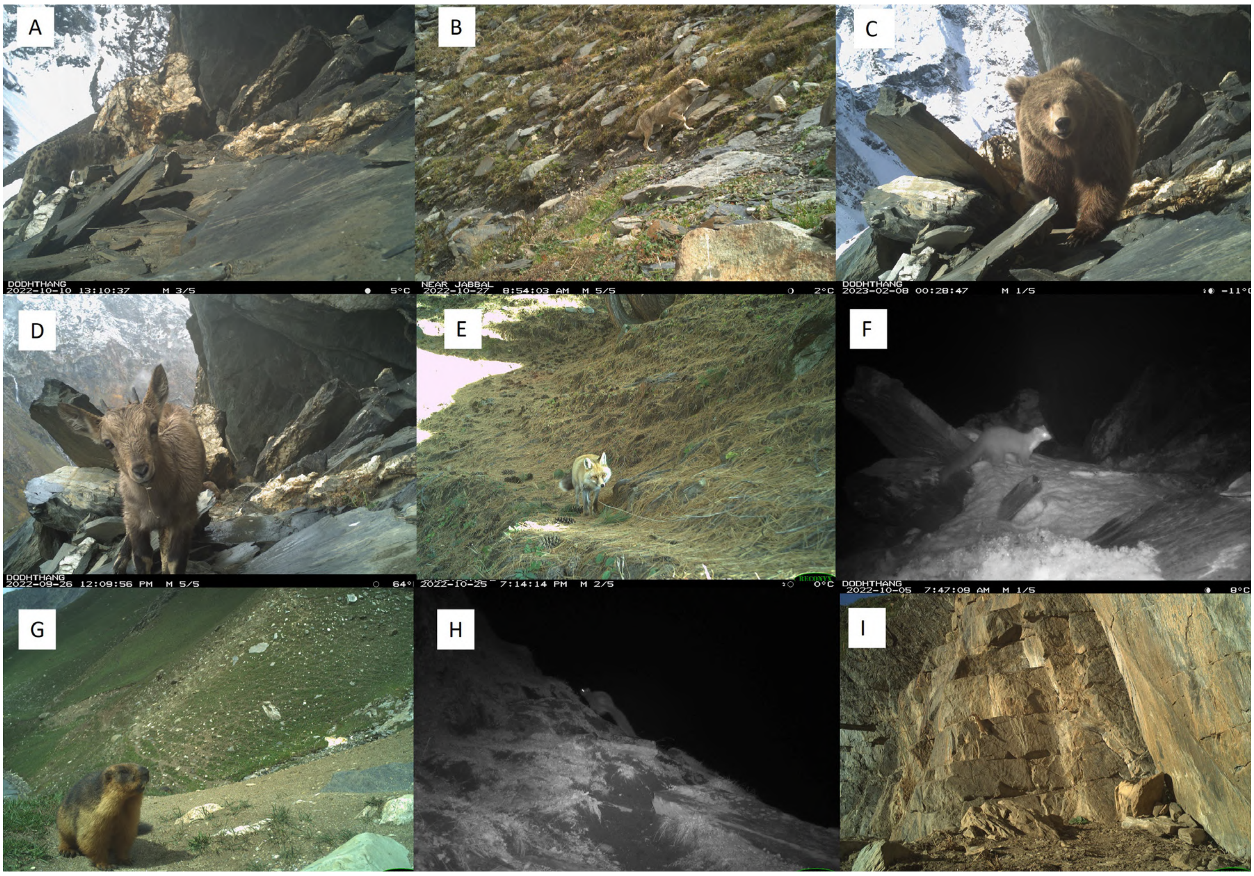


Figure 6. *A panel showcasing select images from camera trapping in Warwan (2022). A: Snow Leopard, B: Himalayan Wolf, C: Himalayan Brown Bear, D: Asiatic Ibex. E: Red Fox, F: Stone Marten, G: Long-tailed Marmot, H: Kashmir Flying Squirrel, I: Himalayan Stoat.*

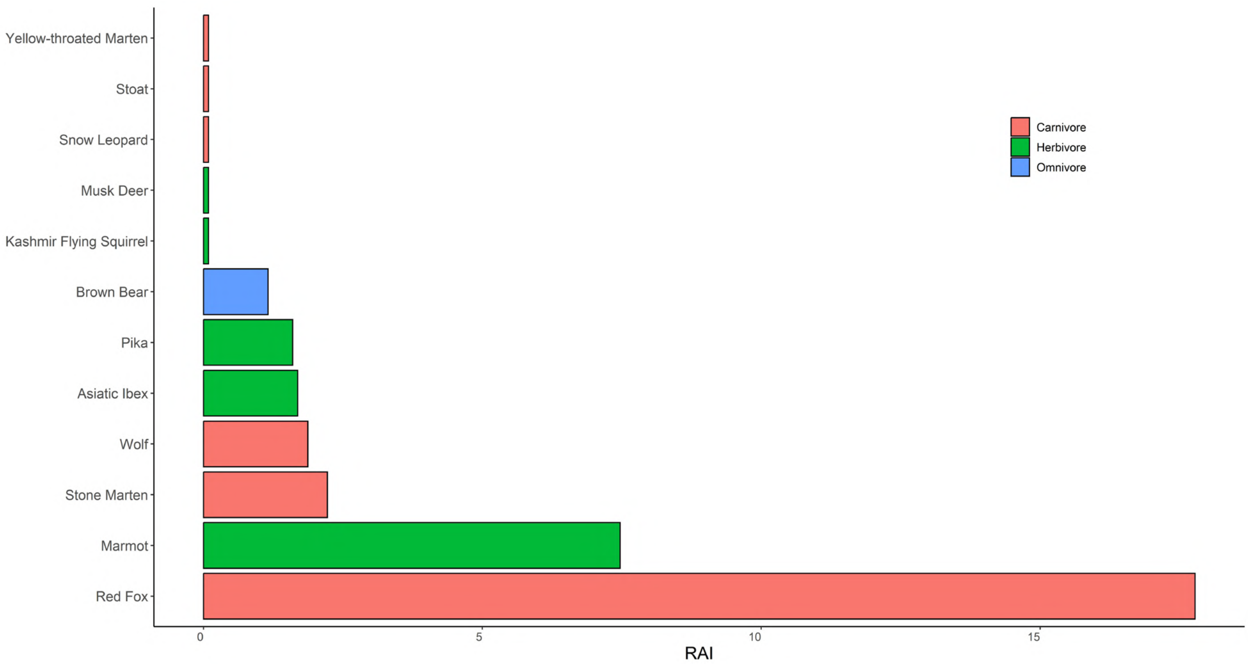


Figure 7. *RAI for species of mammals across Warwan (2022).*

Activity pattern analysis

Across a total of 3,120 camera trap nights, 2,340 in Paddar and 780 in Kishtwar High Altitude National Park (KHANP), we recorded 13 mammal species. Of these, six species had sufficiently large sample sizes to allow for the analysis of activity patterns: Himalayan brown bear (*Ursus arctos isabellinus*), pika (*Ochotona spp.*), red fox (*Vulpes vulpes*), Asiatic ibex (*Capra sibirica*), snow leopard (*Panthera uncia*), and stone marten (*Martes foina*).

The overall activity pattern of all recorded mammal species indicated a predominance of nocturnal behavior (Figure 8). Site-wise comparisons revealed a higher level of nocturnal activity in Paddar compared to Kiyar, KHANP (Figure 9). Activity patterns of the six most frequently detected species across both sites (Figure 10) showed notable interspecific and site-level variation in the timing of activity peaks.

Red fox displayed more pronounced crepuscular activity in Kiyar, KHANP, whereas in Paddar, its activity skewed toward the nocturnal period, potentially reflecting behavioral adaptations to local human disturbance. Asiatic ibex exhibited a consistently diurnal activity pattern across both sites. Snow leopard activity showed crepuscular peaks, which were more prominent in Paddar. Pika maintained relatively steady activity throughout daylight hours in KHANP but highly reduced activity in Paddar during the daytime. Stone marten was nocturnal across both regions, with comparatively more shift in nocturnal activity in Paddar.

Pooled activity data (n = 591) revealed a bimodal pattern, with activity peaks around 03:00 and 21:00 hours. Site-specific patterns indicated higher overall activity levels in KHANP during daytime hours, while in Paddar, mammal activity was significantly reduced, likely suggesting an avoidance of human-associated risk or disturbance.

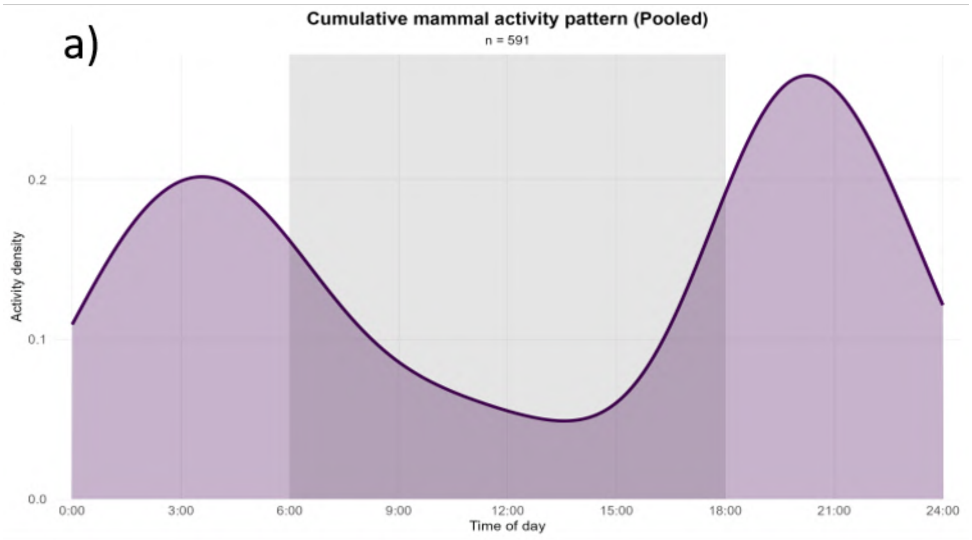


Figure 8. *Overall mammalian activity pattern in Paddar and KHANP (pooled data).*

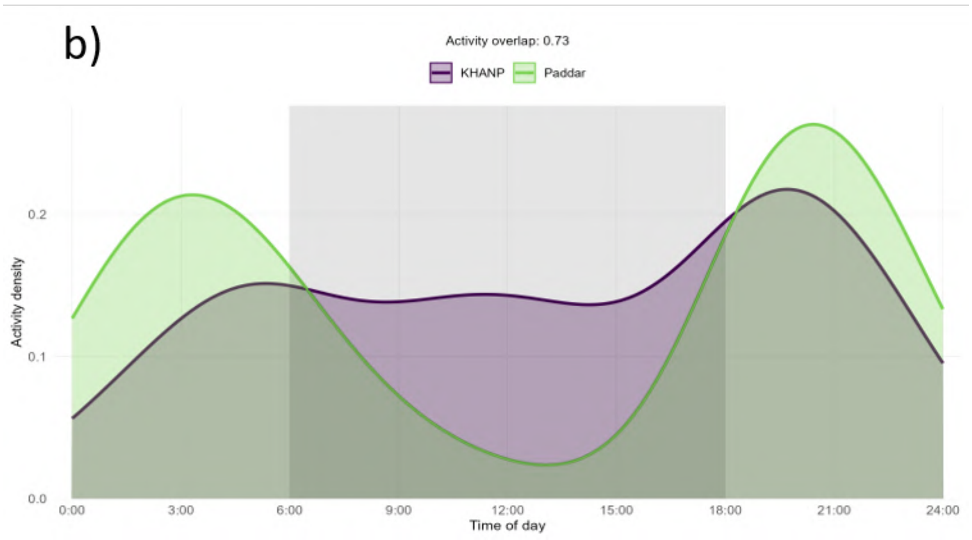


Figure 9. *Site-wise comparison of mammalian activity patterns.*

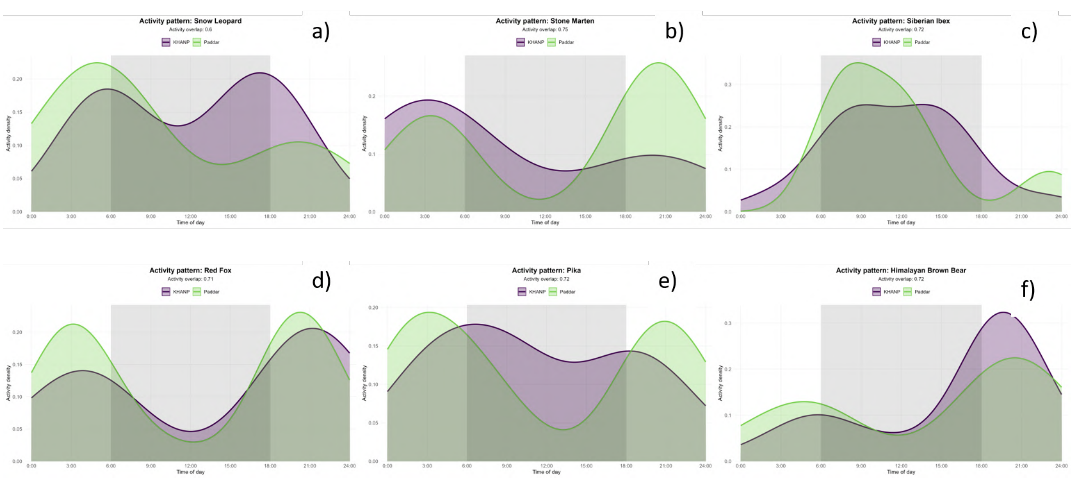


Figure 10. *Site-wise comparison of activity patterns for six species a) Snow leopard, b) Stone martin, c) Asiatic Ibex, d) Red fox, e) Pika, and f) Himalayan brown bear.*

Capacity Building

A key aspect of our work in Jammu & Kashmir has been building local capacity by sharing knowledge and conducting training with frontline staff, local youth, and researchers to support ecological field surveys, with a particular focus on snow leopards.

During the project, our outreach efforts focused on strengthening local capacity and raising conservation awareness among frontline forest staff, college students, School students and local youth. A central goal was to train them in ecological field methods relevant to snow leopard research and monitoring.
Through a series of six workshops, we engaged a diverse group of participants: 480 school students, 500 undergraduate students, 30 postgraduate students, and 30 frontline staff from the Forest Department.

In the Kiyar Valley of Kishtwar High Altitude National Park (KHANP), camera trap activities were independently carried out by trained local youth, through the support of Nature Conservation Foundation (NCF).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Threat Assessment

To evaluate patterns of human-wildlife conflict and prospects for coexistence, we conducted a questionnaire-based survey across four key regions of Kishtwar: Marwah, Warwan, Dachhan, and Paddar. The survey covered approximately 320 households, particularly focusing on communities living in close proximity to Kishtwar high-altitude National Park, forests and high-altitude rangelands.

Preliminary findings reveal a two-fold dynamic: communities experience substantial losses to crops and livestock, both vital to their subsistence and income, due to wild herbivores and carnivores. In response, people often resort to guarding, chasing wildlife away, and in some cases, engaging in retaliatory killings. These interactions suggest both the pressures faced by rural livelihoods and the risks posed to local wildlife populations. The assessment underscores the need for context-specific mitigation strategies that can reduce economic losses while fostering conditions for coexistence

Discussion

This study is one of the first robust systematic sampling efforts of snow leopard populations in the Union Territory of Jammu and Kashmir, India. Despite harboring large areas of potential snow leopard habitats, such as KHANP, the UT lacked validation and robust estimations of snow leopard numbers. To date, population density and abundance of snow leopards have been estimated for two of the five landscapes, namely, Paddar and KHANP, whereas snow leopard presence was confirmed from the Thajawas-Zojila and Warwan landscapes. Given the presence of a diversity of prey species, coupled with the contiguity of the Greater and trans-Himalayan regions, the results of this study indicate that the five landscapes are important for snow leopard conservation.

Additionally, our recent camera trap effort (Nov 2024 to May 2025) also recorded snow leopards in Paddar during the winter months, which provides valuable evidence of their year-round presence in this landscape. This finding is particularly significant given that previous assumptions, shaped largely by a lack of winter camera trapping, suggested that snow leopards in Paddar might be seasonal migrants, using the area primarily in summer and autumn, and moving to adjacent habitats during winter.

The estimated abundance of four (95% CI 4-9 individuals) and five (95% CI 5-13 individuals) in KHANP and Paddar, respectively, are comparable to abundance estimates across each of the low and unknown strata sites sampled in Himachal Pradesh, such as Bharmour, Miyar, Kullu and Baspa (Suryawanshi et al., 2021). For 2024, estimated abundance was three (95% CI 2-11 individuals) and five (95% CI 4-13 individuals) in Kiyar, KHANP and Paddar, respectively. Noteworthy to mention, we only sampled the Kiyar valley of KHANP in 2024. Contrastingly, the sigma parameter for snow leopards at KHANP and Paddar, 4831m (95% CI: 2797-8343), was lower than that for snow leopard estimates in nearby regions. This suggests that the snow leopard populations could be more restricted (Efford et al., 2016). Another possible explanation for the lower sigma parameter could be due to low capture rates. Similarly, there were only three snow leopard detections at Thajawas. Significantly more research is required to estimate and monitor snow leopard population dynamics in the region. Moreover, understanding how these landscapes are ecologically connected, particularly in terms of animal movement and habitat connectivity, is essential for developing informed landscape-level conservation strategies.

In KHANP (2023) and Warwan (2022), marmots had the highest RAI. Studies have highlighted the reliance on seasonally abundant marmots in the Tajik Pamirs as prey (Kachel et al., 2022), a pattern that may also be observed in the landscapes studied in this area. However, in 2024, the Himalayan brown bear and red fox had the highest RAI in Kiyar and Paddar. Further studies, with year-round data, are required to validate this. Additionally, previous research has found that the snow leopard population and distribution are dependent on wild ungulate abundance (Suryawanshi et al., 2021). In our 2024 survey, ibex had a comparable RAI to snow leopards in Paddar and a significantly higher RAI in KHANP. This contrasts with 2023 data, where ibex RAI in Paddar was much lower relative to snow leopards. These patterns could suggest interannual variation in prey availability, which may influence snow leopard distribution and detectability across sites and needs further investigation.

Pikas are found in high relative abundance in both KHANP and Paddar. Previous studies have identified the presence of pikas in the snow leopard diet (Lyngdoh et al., 2014). Provided the relatively lower abundances of ungulates in both regions, there is a possibility of pikas compromising a crucial portion of the snow leopard diet. However, dietary preferences of snow leopards in the region require a comprehensive analysis.
In terms of sympatric carnivores, common leopards were not detected across any sites in 2023. However, during the 2024–25 survey, both snow leopards and common leopards were recorded at multiple sites in Paddar-Hamori and Machail. This co-occurrence conforms with observations from other parts of the Greater Himalayas, such as Himachal Pradesh and Uttarakhand (Suryawanshi et al., 2021; Pal et al., 2022), suggesting potential spatial or temporal overlap between these apex predators. Previous studies have suggested that the high rates of local extinction of common leopards within KHANP's higher elevation region (Kichloo et al., 2023) are due to habitat loss. Additionally, our preliminary results from threat assessment also indicate loss of wildlife due to hunting for trade and sustenance, and retaliatory killings. Further research on this should be prioritized to identify and mitigate potential threats to snow leopard and sympatric mammal conservation.

The Himalayan brown bear occurred across all landscapes in the Kishtwar Himalayas. Though potential spatial avoidance between snow leopards and brown bears has been identified (Patel et al., 2023), more robust studies on

ecological niche partitioning are required. This is particularly important due to evidence of climate change induced range and dietary shifts of Himalayan bears (Nawaz et al., 2019). With glacial melting in the Greater Himalayas occurring at nearly twice the rate of the rest of the planet, snow leopard habitat is severely threatened (Khicloo et al., 2023). This could potentially escalate the intensity and frequency of snow leopard and human interactions. Elaborate studies of human-snow leopard conflict, incorporating livestock-wild ungulate interactions and climate change, might also prove useful for snow leopard conservation.

The activity pattern analysis reveals a predominantly nocturnal trend among high-altitude mammals, with site-specific variations. Species in Paddar showed greater nocturnality than those in KHANP, likely due to higher human disturbance. These observations are in consonance with global evidence that mammals shift toward nighttime activity to avoid humans (Gaynor et al., 2018). Carnivores like the red fox and snow leopard exhibited stronger nocturnal shifts in Paddar, consistent with findings that predators adjust activity to human presence (Van Scoyoc et al., 2023). Smaller species like pikas and stone martens reduced daytime activity in Paddar. While such plasticity may reduce conflict, it could also impair foraging efficiency and disrupt ecological interactions (Gaynor et al., 2021). In contrast, the Asiatic ibex remained diurnal, possibly due to reliance on visual predator detection (Namgail et al., 2012. This supports the "human shield hypothesis" where prey species may increase diurnally in human-dominated areas (Van Scoyoc et al., 2023).
To conclude, it is critical that the Kishtwar landscape, connecting Warwan, Paddar and KHANP, is considered as a unit for landscape-based participatory conservation according to the Government of India's Project Snow Leopard (PSL, 2008). This will require the participation of local communities. This is also consistent with the Kunming-Montreal Global Biodiversity Framework, which recognizes the role that indigenous people and local communities play in global conservation.

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