



Snow Leopard (*Panthera uncia*) Status in China

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This article forms part of a Special Issue on the country-level status of snow leopards. All contributions were reviewed by members of the Snow Leopard Reports Editorial Team and did not undergo external peer review.

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KEYWORDS:

China; conservation; country status; distribution; *Panthera uncia*; population; snow leopard

1. Distribution

China holds the largest proportion of the global snow leopard (*Panthera uncia*) range, with over 60% of the species' potential habitat located within its borders (McCarthy et al., 2017; Shi et al., 2024). Snow leopards are known to occur across eight provinces and autonomous regions in China: Tibet Autonomous Region, Xinjiang Autonomous Region, Qinghai, Gansu, Sichuan, Yunnan, Inner Mongolia Autonomous Region, and Ningxia Autonomous Region. Among these, Tibet Autonomous Region, Xinjiang Autonomous Region and Qinghai contain the largest extent of snow leopard habitat. According to the updated distribution map based on the IUCN Red List range classification (Figure 1b), the 'Extant' snow leopard range in China is estimated at 778,756 km², and the 'Possibly Extant' range is 618,573 km², totaling 1,397,329 km². Other previous estimates predicted 2,168,754 km² 'Extant' range and 52,728 km² 'Possibly Extant' range (McCarthy et al., 2017) and 1,216,289 km² of suitable habitat in China (Li et al., 2016a). These differences largely reflect methodological approaches, as earlier range estimates were primarily expert-derived, whereas the updated map is based on occurrence-driven habitat modelling and subsequently refined through expert validation, resulting in a more spatially explicit delineation of suitable habitat.

Snow leopard ranges in China are primarily distributed on the Tibetan Plateau and in surrounding mountain ranges, including the Himalaya, Hindu Kush, Pamir, Kunlun, Tian Shan, Altai, and Hengduan mountain ranges. The Qilian, Altai, and Tian Shan-Pamir-Hindu Kush-Karakoram mountain ranges are identified as the most likely to remain

stable snow leopard habitats in the face of climate change (Li et al., 2016a).

Although parts of Yunnan, Inner Mongolia, and Ningxia Autonomous Region fall within the species' historical range, recent records from these areas are sparse. In 2013, a young male snow leopard was observed in unusual habitat in Inner Mongolia Autonomous Region, roughly 40 km from Helan Shan, where the species had not been recorded for over three decades; the individual was subsequently captured and relocated (Shi et al., 2024). More recently in August 2024, snow leopards were recorded by camera traps in a Nature Reserve in Inner Mongolia Autonomous Region located on the northern slopes of the Yinshan Mountains and bordering Mongolia to the north (Bayan Nur Urat Desert Nature Reserve, 2025). In 2020, camera traps recorded video evidence of snow leopards in Helan Mountain National Nature Reserve at the border of Inner Mongolia and Ningxia Autonomous Region, representing the first confirmed presence in Helan Mountain in nearly 50 years (Shi et al., 2024). While in Yunnan province, camera traps documented snow leopard presence in February 2024 (State Council News Office of the People's Republic of China, 2024) and August 2024 (Yunnan Baima Snow Mountain National Nature Reserve Administration, 2025) at two neighboring locations approximately 50 km apart.

China shares over 10,000 km of national borders with 10 of the other 11 snow leopard range countries (Shi et al., 2024). Snow leopards have been recorded crossing international borders into countries like Nepal and India, underscoring the critical need for transboundary collaboration for long-term conservation (Subba et al., 2025).

Based on the updated distribution map, a substantial proportion (19%) of China's 'Extant' snow leopard range falls within legally designated protected areas, including protected areas (National Nature Reserves and National Parks) such as Sanjiangyuan, Qomolangma, Altun, and Qilian Mountains. However, connectivity between protected areas remains limited in some regions, and several important snow leopard landscapes remain outside formal protection, particularly in parts of western Sichuan, northern Xinjiang Autonomous Region, and eastern Tibet Autonomous Region.

At present, there are insufficient data to assess national-level trends in snow leopard distribution across China. However, localized records suggest a mixed picture. Occasional detections in historically occupied sites, such as Helan Mountain, may indicate limited reoccupation or increased survey effort, but they do not reflect broad recovery. In contrast, predicted local extirpations in parts of Xinjiang and Inner Mongolia Autonomous Region

(the margins of their range in China), where snow leopards were historically present but have not been reported for decades despite increasing camera trap and survey coverage, suggest a contraction in the species' distribution in some marginal areas.

Insights from population genomics help place these patterns in a longer-term context. Population genomic analysis of snow leopards (Yang et al., 2025) reveals two major genetic lineages: a northern lineage and a southern lineage. The southern lineage remains centred in the Qinghai–Tibet Plateau and adjacent mountains, while the northern lineage shows evidence of a long-term decline beginning around 1,000 years ago, with the loss of many eastern populations from their historical range (Figure 1b). This broader pattern is consistent with the apparent contraction at the margins of the current distribution.

1.1 Modeling the Global Distribution of Snow Leopard Habitat Using the MaxEnt Model

Within the global distribution range of snow leopards, we initially compiled 6,989 snow leopard occurrence records (2000–2025) with precise GPS locations from multiple existing datasets, after removing duplicate records. These data comprised:

- Occurrence records from Li et al. (2020). A total of 1,914 historical records originating from the 2008 Beijing Snow Leopard Forum were excluded because they lacked clear temporal information (potentially dating to the last century), resulting in 4,338 retained records.
- Records from the Global Biodiversity Information Facility (GBIF) database with precise locations ($n = 61$).
- Global snow leopard occurrence records compiled by Liang (2023) ($n = 910$).
- Camera trap–recorded occurrences from the Tibet Autonomous Region, China, reported by Bian et al. (2023) ($n = 308$).
- Camera trap–recorded occurrences from the Sanjiangyuan region, China, collected by the Shan Shui Conservation Center (SSCC), Peking University (PKU), Plateau Nature Conservancy, and the Nyanpo Yutse Conservation Association, as reported in Li et al. (2025) ($n = 289$).
- Camera trap–recorded occurrences from the Qinghai Province, China, collected by Qinghai Normal University (QHNU) ($n = 69$).
- The national-scale camera trap and genetic database maintained by SSCC/PKU ($n = 1,014$).

We further compiled 2,159 snow leopard occurrence records without precise GPS coordinates from within

China for the period 2000–2025. These records were obtained from published literature (n = 1,384), news reports (n = 42), and expert records (n = 733) (Supplementary Materials). Where available, occurrence locations were georeferenced by digitizing snow leopard distribution or occurrence maps. When maps were not provided, locations were assigned to the centroid of the smallest identifiable administrative unit (e.g. village, township, or Nature Reserve) and treated as imprecise occurrence points.

The study extent for the MaxEnt model was defined as a 500 km buffer (Li et al., 2016a) surrounding all 9,148 compiled snow leopard occurrence records, including both precise (n = 6,989) and imprecise (n = 2,159) points. Only the 6,989 precise occurrence records were used in the MaxEnt model. The imprecise occurrence records were excluded from model training but were used to define the spatial extent of the study area, ensuring broader geographic coverage of the species' range. To reduce spatial clustering and potential spatial autocorrelation among occurrence records, we applied spatial thinning using four minimum distance thresholds: 1, 5, 10, and 30 km. This resulted in four filtered datasets containing 2,482, 1,139, 700, and 319 occurrence points, respectively. To assess the influence of thinning distance on model performance, we compared models across the four datasets. The average test Area Under the Curve (AUC) was highest at the 5 km thinning distance (0.911), compared with 1 km (0.880), 10 km (0.907), and 30 km (0.890). Based on this comparison, a 5 km thinning distance was selected for subsequent modeling, resulting in a total dataset of 1,139 occurrence points. This comparison provides a simple sensitivity check on the influence of thinning distance on model performance.

We selected 39 environmental variables to fit the snow leopard habitat suitability model, including:

- 19 bioclimatic variables from the global climate database WorldClim 2.1 (30 arc-seconds resolution);
- 14 land-use factors from the University of Maryland's Global Land Use Harmonization dataset (LUH, 0.25° resolution);
- 4 topographic variables: elevation, slope, aspect, and terrain ruggedness index (TRI). Elevation data came from the 15 arc-seconds GEBCO layer, while slope, aspect, and TRI were derived from the elevation layer using spatial analysis tools in QGIS;
- 1 vegetation variable: Normalized Difference Vegetation Index (NDVI), sourced from NASA's MOD13Q1 (Terra, 250 m resolution);
- 1 human impact variable: Human Footprint Index (HFI), from the global 100-meter resolution terrestrial human footprint dataset (<https://datadryad.org/dataset/doi:10.5061/dryad.ttdz08m1f#usage>).

All variables were resampled to a uniform resolution of 30 arc-seconds.

We analyzed correlations among all environmental variables and, for highly correlated variables (correlation coefficient > 0.8), retained only those with higher contribution to the MaxEnt model. Variables contributing less than 0.2% to the model were excluded. Ultimately, 11 environmental variables were selected to build the snow leopard habitat suitability model, including: elevation, slope, terrain ruggedness index (TRI), annual mean temperature (bio1), maximum temperature of the warmest month (bio5), temperature annual range (bio7), mean temperature of the wettest quarter (bio8), mean temperature of coldest quarter (bio11), C3 annual crops (c3ann), and rangeland (range), potentially forested secondary land (secdf).

In the MaxEnt model, 70% of the data were used for training and 30% for testing. The model was run 10 times with repeated fittings, and the average result was retained. Model performance was evaluated using the AUC metric, with a mean AUC of 0.911 indicating good performance. We used the threshold corresponding to the maximum training sensitivity plus specificity logistic threshold (0.2678) to delineate potential suitable habitat for snow leopards from the habitat suitability map.

1.2 Post-processing the Habitat Suitability Map to Generate the Snow Leopard Range Map

To reduce fragmentation in the habitat suitability map, we applied a moving window smoothing technique with a 5-pixel circular window to the binary habitat classification (suitable/unsuitable) derived from the MaxEnt model. The majority filter reclassified each central pixel based on the most common value within its neighborhood. Subsequently, we removed habitat patches smaller than 50 km² and more than 30 km away from other patches as these small, isolated patches are unlikely to sustain snow leopards and may represent noise in the model predictions rather than actual habitat. We also filled holes smaller than 50 km² inside large habitat patches.

To define the currently 'Extant' range, we screened the full set of 9,148 snow leopard occurrence records and excluded records older than 10 years (i.e. prior to 2015), retaining 8,748 recent occurrence records. We classified suitable snow leopard habitat at the level of watershed units, as these provide a consistent spatial framework for assigning occurrence records within suitable habitat. Given that published home range estimates for snow leopards vary widely across the range, and are often based on limited sample sizes of resident adults and may include dispersing individuals (Yu et al., 2022; Shrestha et al.,

2025; Subba et al., 2025), we applied a movement-based approach to represent the likely area a snow leopard could use around a recorded location. We used a radius of 20 km around occurrence records to approximate this potential movement, equivalent to an area of approximately 1,257 km². To remain conservative, we applied a standardized buffer of 1,000 km² (equivalent to a radius of 17.8 km). Watersheds overlapping by at least 10% with these buffers were classified as having snow leopard presence. Suitable habitat within such watersheds (i.e., those with snow leopard occurrence records) was defined as ‘Extant’ habitat, whereas suitable habitat in all other watersheds without occurrence records was classified as ‘Possibly Extant’. Here, ‘Extant’ follows IUCN range terminology and refers to areas considered currently occupied based on recent occurrence evidence, whereas ‘Possibly Extant’ refers to

suitable areas where current presence remains uncertain.

Watershed delineation was conducted using ArcGIS software and the *Hydrology* toolset. The process began with the GEBCO elevation dataset (as described above), which was processed using a *Fill* operation to remove spurious sinks and depressions. Flow direction was then calculated to determine the primary direction of water movement for each grid cell, followed by computation of flow accumulation to estimate upstream contributing areas and identify channel networks using a threshold value of 800. Finally, watersheds were delineated using the *Watershed* tool, with defined pour points (outlets) as inputs. The mean area of the delineated watersheds was 1,088 km².

Table 1. Expert-validated revisions to snow leopard distribution status based on comparison between the 2017 IUCN range map and the updated, model-based range map.

ID	Region (Province)	Previous IUCN Range (McCarthy et al., 2017)	Updated IUCN Range (2026)	Expert Assessment	Final Distribution Classification	Area (km ²)
1	Longshou Mountain (Gansu)	Possibly Extant	Possibly Extant	Possibly Extinct	Possibly Extinct	999
2	Tuoli (Xinjiang)	Extant	Extant	Possibly Extinct	Possibly Extinct	489
3	Lang Mountain (Inner Mongolia)	Possibly Extant	Non-habitat	Possibly Extinct	Possibly Extinct	2,513
4	Wula Mountain (Inner Mongolia)	Possibly Extant	Non-habitat	Possibly Extinct	Possibly Extinct	745
5	Daqing Mountain (Inner Mongolia)	Possibly Extant	Non-habitat	Possibly Extinct	Possibly Extinct	2,183
6	Yabulai Mountain (Inner Mongolia)	Possibly Extant	Non-habitat	Possibly Extinct	Possibly Extinct	950
7	Beida Mountain (Inner Mongolia)	Possibly Extant	Non-habitat	Possibly Extinct	Possibly Extinct	293
8	Buerjin (Xinjiang)	Extant	Non-habitat	Possibly Extinct	Possibly Extinct	852
9	Hoboksar and Emin (Xinjiang)	Extant	Extant, Possibly Extant	Possibly Extant (seasonality uncertain)	Possibly Extant (seasonality uncertain)	2,438
10	Wuqia (Xinjiang)	Possibly Extant	Extant, Possibly Extant	Extant (with evidence)	Extant	15,904
11	Qapqal, Western Tianshan (Xinjiang)	Possibly Extant	Extant, Possibly Extant	Extant (with evidence)	Extant	935
12	Qinling Mountains (Shaanxi)	Non-habitat	Possibly Extant	Non-habitat	Non-habitat	1,650
13	Helan Mountain (Ningxia and Inner Mongolia)	Possibly Extant	Extant	Extant (with evidence)	Extant	776
14	Gonghe (Qinghai)	Possibly Extant	Possibly Extant	Extant (deductive)	Possibly Extant	2,553
15	Geermu (Qinghai)	Possibly Extant	Extant	Extant (deductive)	Extant	2,388
16	Bayan Nuru Mountain (Inner Mongolia)	Non-habitat	Non-habitat	Extant (seasonality uncertain, with evidence)	Extant (seasonality uncertain)	417
17	Wuliji (Inner Mongolia)	Non-habitat	Non-habitat	Extant (seasonality uncertain, with evidence)	Extant (seasonality uncertain)	417
18	Mazong Mountain (Gansu)	Possibly Extant	Non-habitat	Extant (seasonality uncertain, with evidence)	Extant (seasonality uncertain)	417

Note: Grey indicates changes after expert consultation on the updated range map.

1.3 Expert Consultation to Verify Snow Leopard Distribution Changes

We overlaid the updated snow leopard range map with the 2017 IUCN snow leopard range map to identify areas where potential changes in distribution status, such as local extinction or colonization, may have occurred. We focused on spatial discrepancies between the two maps that required further verification (Figure 1a), particularly areas classified as ‘Extant’ or ‘Possibly Extant’ in the IUCN map but identified as non-habitat in the updated range map.

To validate these areas, we consulted 12 national experts with extensive field survey experience and knowledge. Based on consultation with 12 experts, revisions were made to 12 regions and three new regions were added to the updated range map (Table 1). The final IUCN snow leopard range map, integrating MaxEnt model outputs, recent occurrence records, and expert consultation, is presented in Figure 1b. The updated ‘Extant’ range was estimated at 778,756 km², with a ‘Possibly Extant’ range of 618,573 km², resulting in a total range of 1,397,329 km². In addition, 9,024 km² was classified as ‘Possibly Extinct’.

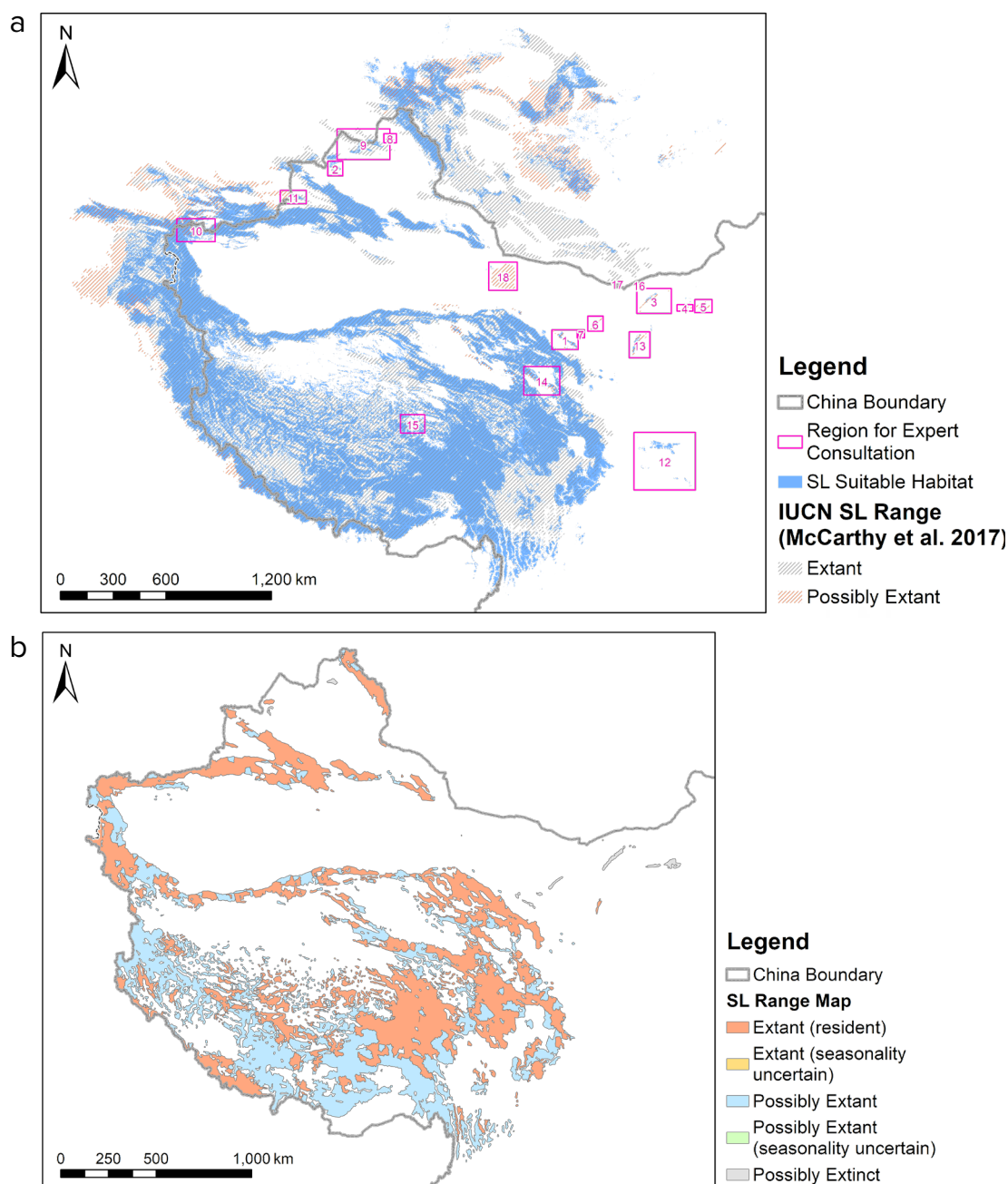


Figure 1. (a) Overlay of the 2017 IUCN snow leopard range map and the MaxEnt-derived habitat suitability map, highlighting regions with potential changes in distribution status and the 18 areas subjected to expert consultation. 1. (b) Revised IUCN snow leopard range map incorporating MaxEnt model outputs, recent occurrence records, and expert validation.

2. Population

Within China, early estimates suggested a snow leopard population of 2,000–2,500 individuals, representing approximately one-third to one-half of the global wild population (McCarthy and Chapron, 2003). A more recent assessment estimated an overall population of approximately 4,500 individuals in China, roughly double earlier estimates (Riordan and Shi, 2016). Although site-level estimates of snow leopard density have increased across China, large-scale systematic assessments (>10,000 km²) have been lacking. Based on a synthesis of systematic survey efforts conducted up to 2018, only approximately 1.7% of suitable snow leopard habitat in China had been scientifically sampled for density and abundance (Liu et al., 2019).

Based on published papers and reports, at least 66 site-level snow leopard population surveys have been conducted across China to date (December 2025), the majority of which employed camera trap methods (Table S1). These 66 survey sites were distributed across five provincial-level regions (Qinghai, Tibet Autonomous Region, Xinjiang Autonomous Region, Gansu, and Sichuan), with Qinghai Province hosting the largest number of studies ($n = 19$), particularly within the Sanjiangyuan and Qilian Mountains. Surveyed areas ranged from small-scale sites of approximately 30 km² to large landscapes exceeding 6,100 km². Most density estimates were derived from camera trap data analyzed using spatially explicit capture–recapture (SECR) models, with multi-session SECR approaches increasingly applied in recent years. Density estimates from the most robust local studies in China show considerable variation, ranging from 0.90 individuals per 100 km² in the Sanjiangyuan region of Qinghai Province (Li et al., 2025) to 1.40 individuals per 100 km² in the central Tibetan Plateau (Bian et al., 2023).

The first large-scale snow leopard population assessment conducted in China was recently completed in the Sanjiangyuan region of Qinghai Province, covering a total surveyed (mask) area of 32,899 km², with population estimates extrapolated to approximately 360,000 km² (Li et al., 2025). This study integrated and standardized camera trap data from 12 sites collected between 2015 and 2021 and estimated an average snow leopard density of 0.90 individuals per 100 km² (95% CI: 0.68–1.21 per 100 km²), corresponding to an estimated total population size of 1,002 individuals (95% CI: 755–1,341) across the entire region. The study also reported a set of more conservative population estimates derived for the survey region, ranging from 971 individuals (95% CI: 732–1,287) to 978 individuals (95% CI: 737–1,267). Even under these conservative

estimates, the Sanjiangyuan region alone is estimated to support approximately 11–21% of the previously estimated global snow leopard population (Li et al., 2025).

A population estimate for the Qilian Mountains is currently underway, covering approximately 14,250 km², alongside a province-level assessment for Sichuan Province with a planned survey area of 44,900 km². Once completed, these assessments will provide robust, landscape-scale population estimates for the Sanjiangyuan region, the Qilian Mountains, and Sichuan Province. Together with other surveyed areas, these sites encompass approximately 110,686 km² of snow leopard habitat, representing 7.9% of the updated snow leopard range in China ('Extant' and 'Possibly Extant' combined; total = 1,397,329 km²).

2.1 China National Population Estimate

Building on earlier efforts, including the 2018 Snow Leopard Network China report (Snow Leopard Network China, 2018), we aimed to produce a robust and updated national population estimate for snow leopards in China. To achieve this, we compiled density estimates from across the country through comprehensive literature searches and expert consultation, drawing on both published and grey literature. National-scale density extrapolation was conducted using a habitat stratification approach as outlined below.

2.1.1 Density Estimates Collection

We collated 41 snow leopard survey-related literature sources from across China, including grey literature. For each survey, we recorded information on geographic location, survey year, survey methods, survey area, the number of identified snow leopard individuals, density estimates, and population size estimates. For surveys that did not report density estimates, we calculated the snow leopard density by dividing the number of identified adult individuals by the reported survey area.

Initially, we compiled data from 95 site-level surveys reporting snow leopard density or abundance estimates across China. To ensure the use of the most reliable and representative estimates, we excluded surveys conducted in the same area, defined as having a high degree of spatial overlap within the same valley, mountain block, or contiguous local landscape unit, retaining only one survey in cases of substantial overlap. Survey area was defined using the spatial extent reported in the original studies, including SECR mask areas, bounding polygons of camera trap arrays, or aggregated survey extents derived from grid-based sampling (e.g. summed 5 km × 5 km cells). When overlap occurred, we prioritized surveys with larger spatial extent and more robust field or analytical methods, such as camera trapping or genetic sampling

combined with spatially explicit capture–recapture (SECR) analyses, as these provide more reliable and comparable density estimates. Survey timing was not used as a primary selection criterion; selection was guided by methodological robustness and spatial independence.

This screening process resulted in 25 sources comprising 66 surveys for analysis, of which 64 employed camera trapping, 50 applied SECR models, and 49 covered survey areas larger than 600 km² (Table 2; Table S1). Surveys using multi-session SECR models that jointly analyzed data from multiple adjacent survey areas were treated as surveys covering areas greater than 600 km², even when individual component survey sites were smaller than this threshold.

Table 2. Provincial summary of snow leopard population survey sites used for national population estimation, showing data collection methods, analytical approaches, and spatial extent.

Province	Number of survey sites	Survey sites using camera trap or genetic methods	Survey sites analyzed using SECR	Survey sites with area ≥600 km ²
Qinghai	19	18	16	16
Gansu	11	11	11	9
Tibet Autonomous Region	17	17	6	8
Xinjiang Autonomous Region	17	16	16	14
Sichuan	2	2	1	2
Total	66	64	50	49

From the dataset of 66 surveys, we applied a priori data quality criteria based on survey timing and statistical outliers. We excluded five surveys conducted before 2015. These surveys covered relatively small areas (<600 km²), which may lead to overestimation of snow leopard density (Suryawanshi et al., 2019), and/or employed methods other than camera trapping or genetic sampling. We then screened for outliers using the interquartile range (IQR) method by calculating the first quartile (Q1), third quartile (Q3), and the IQR (Q3 – Q1). Density estimates falling outside the range [Q1 – 1.5 × IQR, Q3 + 1.5 × IQR] were classified as outliers (Rousseeuw and Hubert, 2011). This resulted in the exclusion of four surveys with density estimates exceeding 2.2 individuals per 100 km².

To assess the impact of these data exclusions, we compared national population estimates generated with and without the inclusion of pre-2015 surveys and statistical outliers. Estimates were consistently higher when early surveys and outliers were retained, indicating that the filtered dataset yielded more robust and conservative population estimates. The effects of excluding early surveys and outliers are reported in Supplementary Results 1 and 2 (Tables S2 and S3). We further examined the sensitivity of population estimate results to the exclusion of surveys with crude density estimates (calculated as the number of adult snow

leopard individuals divided by survey area), which yielded results highly consistent with the main analysis, as reported in Supplementary Results 3 (Table S4).

2.1.2 Habitat stratification

We used Zonation v4 conservation planning software to rank the relative quality of snow leopard habitat predicted by the MaxEnt model. The habitat suitability output was clipped to China’s national boundary and used as the spatial extent for ranking. We applied the Core Area Zonation removal rule, which prioritizes the retention of grid cells with higher habitat suitability values.

To account for the wide-ranging and dispersal capabilities of snow leopards, a smoothing parameter of 30 km was applied during zoning to reduce habitat fragmentation (McCarthy et al., 2005). The edge removal option was selected to prioritize the removal of grid cells from habitat edges, thereby minimizing edge effects in conservation prioritization (Li et al., 2020). This process generated a continuous habitat quality ranking for each grid cell, with values ranging from 0 (lowest priority) to 1 (highest priority).

We plotted the 61 snow leopard density surveys against habitat ranking values and stratified them into three habitat quality classes: low-quality habitat (0.5–0.75), medium-quality habitat (0.75–0.9), and high-quality habitat (0.9–1) (Figure 2a). Given that surveys were largely absent in low-quality habitats (n=8), density extrapolation was restricted to medium- and high-quality habitats with rankings ≥0.75. These two strata comprise 83.5% of the total predicted suitable snow leopard habitat (84.3% of Extant range, 82.6% of Possibly Extant range) (Figure 2b). We further tested alternative threshold values for separating medium- and high-quality habitats, and found minimal impacts on the final population estimates, as reported in Supplementary Results 4 (Table S5).

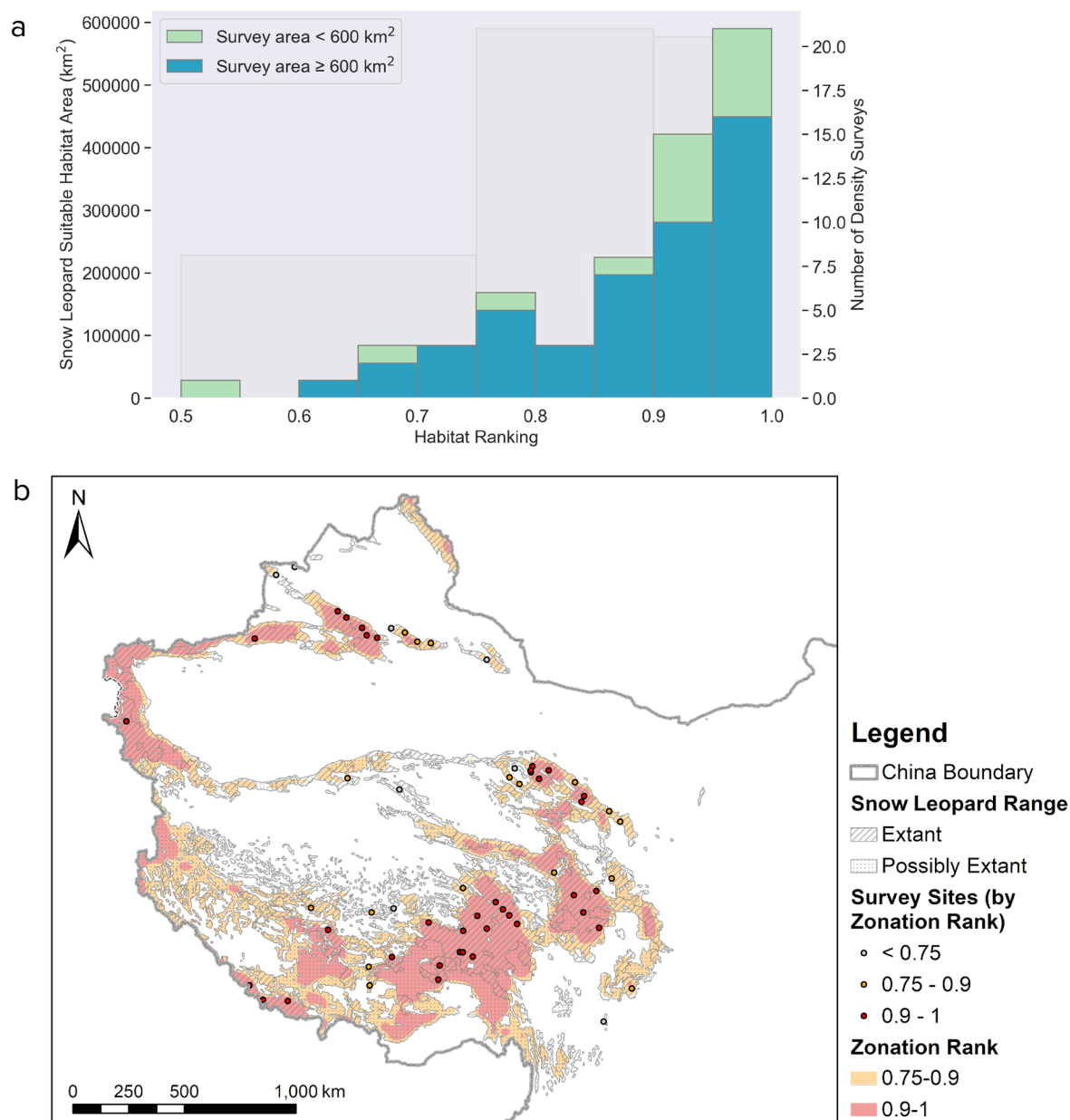


Figure 2. (a) Distribution of predicted snow leopard suitable habitat area along the MaxEnt-derived habitat quality ranking (primary y-axis; grey bars) and the distribution of the 61 population density surveys across habitat ranking classes (secondary y-axis; blue and green bars). **2. (b)** Spatial distribution of the 61 snow leopard density survey sites overlaid on the habitat quality ranking map in snow leopard range.

We note that large areas of western Tibet and Xinjiang Autonomous Region remain unsurveyed. Surveys are also comparatively scarce in lower-ranked habitats, indicating that survey efforts to date have been concentrated in higher-quality snow leopard habitats.

2.1.3 Primary population estimation based on habitat stratification

We first examined the relationship between habitat ranking values and snow leopard density estimates and found a generally positive association (Spearman's $\rho = 0.336$, $p = 0.011$; Figure 3a). Based on this relationship, we calculated average estimates for each habitat quality stratum (Figure 3b).

These stratum-specific density estimates were extrapolated to the corresponding habitat strata within areas classified as 'Extant' in the updated IUCN snow leopard distribution map (Figure 1b) to derive the primary national population estimate (Figure 3c). By multiplying the mean density by the 'Extant' habitat area within each stratum, the total snow leopard population in China was estimated at 5,232 individuals (95% CI: 4,114–6,351) (Table 3). As extrapolation was limited to areas classified as 'Extant' and with habitat rankings ≥ 0.75 (84.3% of Extant range), consistent with IUCN Red List guidance on current occupancy, this estimate is considered conservative; inclusion of 'Possibly Extant' areas and regions with lower habitat rankings would likely increase the total.

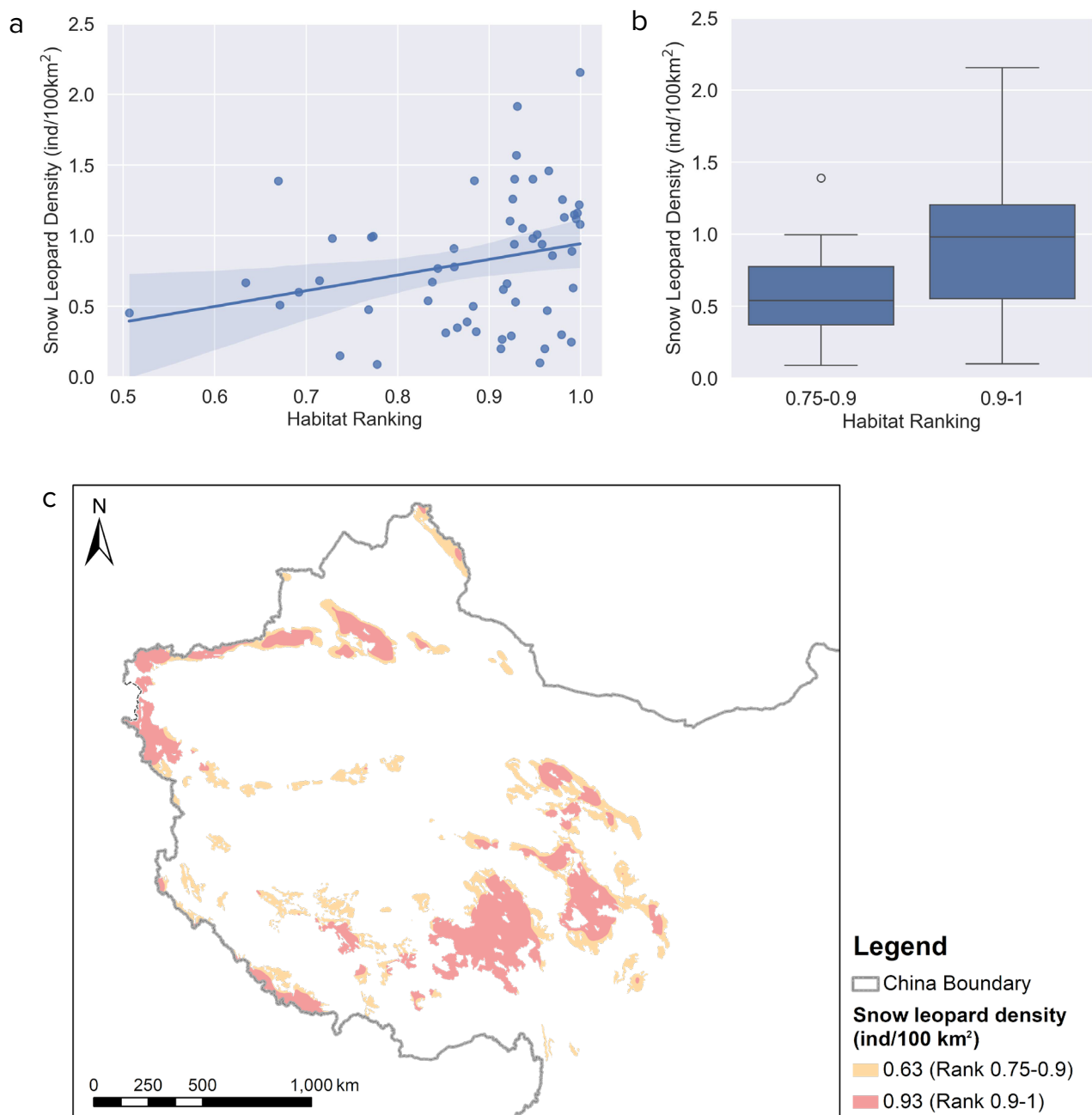


Figure 3. (a) Relationship between MaxEnt-derived habitat ranking values and snow leopard density estimates across surveyed sites. (b) Distribution of snow leopard density estimates within each habitat quality stratum, shown as boxplots indicating the median, interquartile range (IQR), and values within $1.5 \times \text{IQR}$. (c) Extrapolation of stratum-specific mean density estimates to areas classified as 'Extant' in the updated IUCN snow leopard distribution map to derive the primary national population estimate.

Table 3. Stratum-specific snow leopard density estimates (individuals per 100 km²) and extrapolated adult population estimates across the classified 'Extant' range in China. LCL and UCL denote the lower and upper bounds of the 95% confidence interval.

Rank Strata	Density (ind/100 km ²)	Total Area (km ²)	Abundance			
			Mean	SE	LCL	UCL
Medium (0.75–0.9)	0.63	291,085	1,840	257	1,337	2,344
High (0.9–1)	0.93	365,291	3,392	314	2,777	4,007
Total		656,376	5,232		4,114	6,351

Table 4. Provincial-level snow leopard adult population estimates across the ‘Extant’ range in China

Province	Population estimates (95% CI) across ‘Extant’ range
Qinghai	1,765 (1,401–2,129)
Xinjiang Autonomous Region	1,552 (1,217–1,887)
Tibet Autonomous Region	1,401 (1,106–1,696)
Gansu	280 (216–344)
Sichuan	220 (164–276)
Yunnan	14 (10–18)
Total	5,232 (4,114–6,351)

Provincial-level population estimates were derived using the same Extant range extrapolation approach, with stratum-specific density estimates scaled to ‘Extant’ habitat within each province (Table 4). Notably, by focusing on medium- and high-quality habitat only, this approach yields conservative population estimates and may exclude snow leopard populations in marginal range areas such as Ningxia and Inner Mongolia Autonomous Region.

2.1.4 Alternative population estimates and sources of uncertainty

To evaluate the sensitivity of the national population estimate to alternative spatial extrapolation assumptions, we applied two buffer-based extrapolation approaches based on the circular area of 1,000 km² (radius = 17.8 km).

This reflects upper-range estimates of snow leopard space use from GPS-collar studies (Yu et al., 2022; Shrestha et al., 2025; Subba et al., 2025). These approaches were used only for sensitivity analyses and not for the primary estimate. Unlike the primary estimate, which extrapolates across defined ‘Extant’ areas, these approaches restrict extrapolation to suitable habitat areas defined by occurrence records.

In the first approach, stratum-specific density estimates were extrapolated to suitable habitat within a 17.8 km buffer around individual snow leopard occurrence records (Figure 4a). In the second approach, density estimates were extrapolated to suitable habitat within a 17.8 km buffer around the minimum convex polygon (MCP) constructed from occurrence records within each mountain range (Figure 4b). This includes suitable habitat between occurrence points within each range and assumes connectivity within mountain ranges. These two approaches yielded population estimates of 3,037 individuals (95% CI: 2,399–3,675) and 5,308 individuals (95% CI: 4,173–6,443), respectively (Table 5).

Despite representing the most comprehensive national population assessment for snow leopards in China to date, several sources of uncertainty remain. Survey effort is unevenly distributed geographically and is concentrated primarily in higher-quality habitats, while large areas of western Tibet and Xinjiang Autonomous Region remain poorly surveyed. Consequently, density extrapolation may

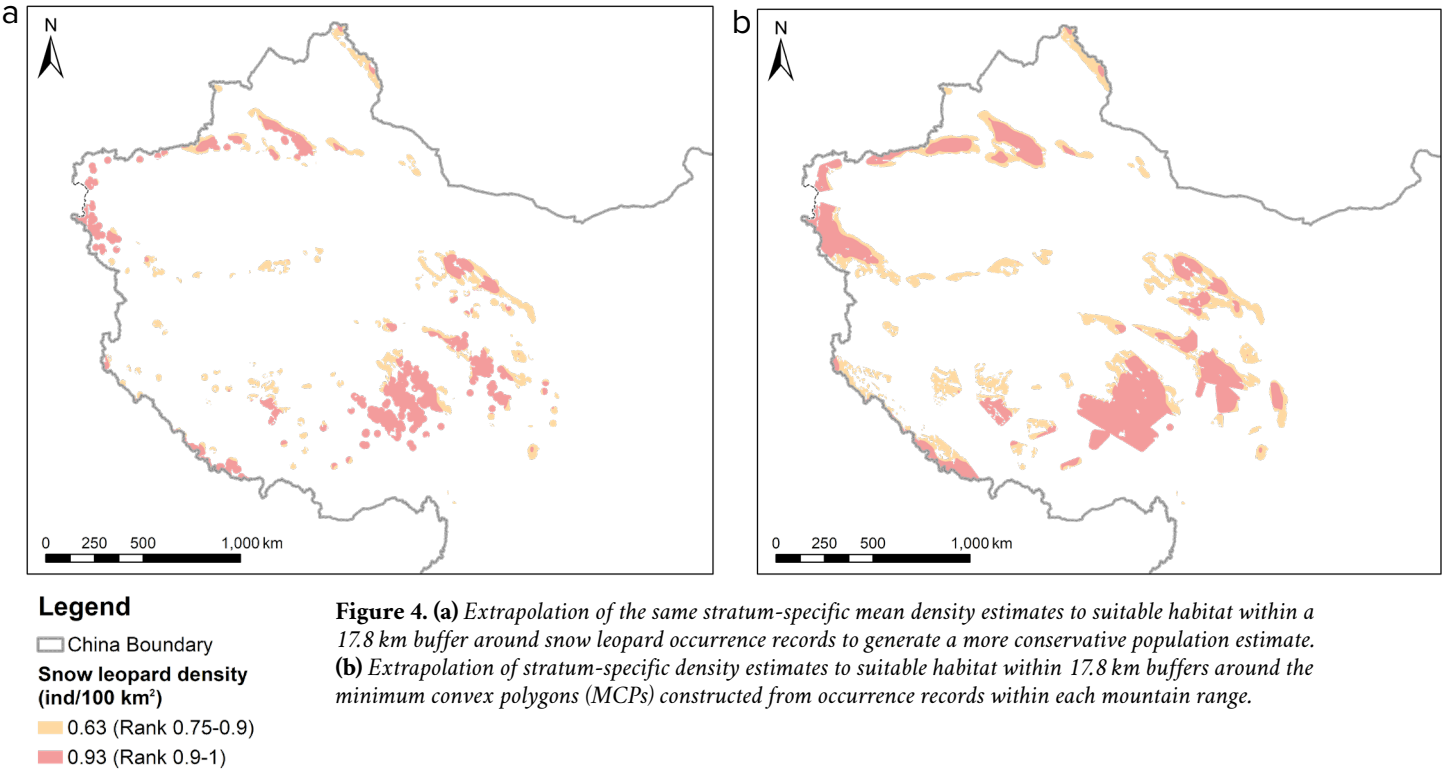


Table 5. Habitat-stratified snow leopard density estimates and extrapolated adult population sizes using buffer-based extrapolation approaches. LCL and UCL denote the lower and upper bounds of the 95% confidence interval.

Extrapolation method	Rank Strata	Density (ind/100 km ²)	Total Area (km ²)	Abundance			
				Mean	SE	LCL	UCL
a) 17.8 km buffer around occurrence records	Medium (0.75–0.9)	0.63	150,094	949	132	689	1,209
	High (0.9–1)	0.93	224,855	2,088	193	1,710	2,466
	Total		374,949	3,037		2,399	3,675
b) 17.8 km buffer around mountain range occurrence records MCPs	Medium (0.75–0.9)	0.63	296,904	1,877	262	1,364	2,391
	High (0.9–1)	0.93	369,475	3,431	317	2,809	4,052
	Total		666,380	5,308		4,173	6,443

be biased toward well-studied core habitats. In addition, extrapolation from site-level density estimates assumes that surveyed areas are representative of broader habitat strata, an assumption that may not hold consistently across China’s ecologically heterogeneous snow leopard landscapes. The number and spatial distribution of available density estimates also remain limited, further contributing to uncertainty. Where sufficient data are available, developing province-level estimates would help address this variation by better capturing variation in density and survey coverage. Nevertheless, by integrating the best available empirical data and explicitly addressing known methodological biases, this framework provides a transparent and reproducible basis for national-scale population estimation that can be progressively refined as survey coverage expands.

We note that in contrast to PAWS approaches, which may extrapolate densities across all suitable habitat, the primary estimate presented here is restricted to areas classified as ‘Extant’. This more conservative approach reflects current data limitations and aims to reduce uncertainty associated with extrapolating densities across large, heterogeneous, and under-sampled areas of China’s snow leopard range. As survey coverage improves, future assessments may move toward broader extrapolation approaches where appropriate.

3. Threats

This review does not aim to provide a comprehensive reassessment of threats to snow leopards in China; a detailed and updated analysis is available in Shi et al. (2024). Snow leopard conservation in China is increasingly shaped by landscape-scale and systemic pressures rather than direct persecution. Rapid economic growth and land-use change in Central and Western China have intensified pressures

from overgrazing, infrastructure expansion, mining, and habitat degradation across much of the species’ range (Chen et al., 2011; Alexander, 2015; Li et al., 2016a; Li et al., 2021). Prey depletion, driven by livestock competition, disease transmission, and free-ranging dog predation, has reduced prey availability and affected snow leopard populations (Li et al., 2019). Large transport and extractive projects in the Tibetan Plateau, Qilian Mountains, and Xinjiang Autonomous Region have introduced roads, noise, pollution, and permanent human presence into previously remote habitats. These developments reduce habitat connectivity and can alter prey distributions.

Climate change represents a pervasive and long-term threat that is likely to amplify existing pressures. Model projections suggest that substantial areas of suitable snow leopard habitat may be lost or fragmented due to upward treeline shifts, contraction of alpine zones, and changes in temperature and precipitation regimes (Forrest et al., 2012; Li et al., 2016a; Li et al., 2021). Climate-driven changes in vegetation structure and productivity are expected to affect wild prey and pastoral systems, causing a decrease in prey resources, with potential consequences for snow leopard distribution and human–wildlife interactions (Shen, 2020; Pörtner et al., 2022). Recent vulnerability assessments indicate that climate impacts may interact with expanding infrastructure and other human pressures, increasing risk in some snow leopard landscapes (Cong et al., 2025).

Policy and land-management interventions have also had unintended consequences for snow leopard conservation. In some regions, marmot and pika control programs implemented for plague prevention or grassland restoration have reduced prey availability (Alexander, 2015; Lambert et al., 2020). Extensive grassland fencing for pasture management has disrupted landscape connectivity, restricted wildlife movement, and caused direct mortality of wild ungulates (Tsering, 2009; Greenfield et al., 2021;

Zahler and Victurine, 2024). These impacts can indirectly affect snow leopards through reductions in prey abundance and mobility.

In contrast to these broad-scale pressures, threats from illegal hunting, trade, and retaliatory killing have declined in importance over recent decades. Strengthened legal protection, improved enforcement, and changing social norms have contributed to reduced levels of direct persecution (Li and Lu, 2014; Li et al., 2013; Hacker et al., 2020; Maheshwari and Niraj, 2018). In many regions, snow leopards account for a relatively small proportion of livestock losses compared to predators such as grey wolves (*Canis lupus*) or livestock disease. Studies indicate that local attitudes toward snow leopards are generally neutral or positive (Tang et al., 2023). The traditional medicinal use of snow leopard parts has largely ceased since the late 1990s (Li et al., 2013).

China contains more than 60% of the global snow leopard range, much of it remote and difficult to access. Research and conservation effort remain uneven and are concentrated largely within protected areas. Habitats outside protected areas, which may be important for dispersal and long-term population connectivity, receive less attention. Limited funding and conservation capacity at local levels further constrain effective threat mitigation in some regions.

4. Conservation

National conservation approaches for snow leopards in China have evolved rapidly over the past two decades. While detailed accounts are available elsewhere (Snow Leopard Network China, 2018; Shi et al., 2024), this section summarizes key policy, institutional, and community-based developments most relevant to current conservation status.

4.1 Policy frameworks and institutional context

Formal protection of snow leopards in China has been underpinned by a strong legal and policy framework. Snow leopards were designated as a Class I National Key Protected Species following the enactment of the *Law of the People's Republic of China on the Protection of Wildlife* in 1988, establishing the legal basis for strict protection (Li et al., 2013; Riordan and Shi, 2016). Subsequent policy reforms have increasingly emphasized ecosystem-level conservation rather than single-species management.

Since 2011, national policy has been strongly shaped by the concept of “ecological civilisation,” which has driven reforms in environmental governance and protected area management (Xu et al., 2017). A central outcome has been

the development of a National Park system intended to consolidate fragmented protected areas into larger, more coherent conservation landscapes.

4.2 Protected areas and landscape-scale conservation

Nature Reserves, as a category of protected areas, currently overlap with approximately 23% of the snow leopard range in China, a proportion higher than the global average of protected area overlap for snow leopards (Deguignet et al., 2014; Wang, 2022). Since 2017, the establishment of pilot National Parks, including Sanjiangyuan, Qilian, and Giant Panda National Parks, has significantly altered the spatial configuration of conservation areas within key snow leopard landscapes (Wang, 2022), and has further strengthened the scope and effectiveness of snow leopard conservation coverage.

The National Park system represents a shift toward landscape-scale conservation planning. This approach is particularly relevant for snow leopards, which require large, connected habitats and regularly move across administrative boundaries (Li et al., 2016b). By integrating previously separate reserves, National Parks aim to improve ecological connectivity and management consistency across snow leopard range areas.

4.3 Human–wildlife conflict and compensation mechanisms

Mitigating human–wildlife conflict has become a core component of snow leopard conservation policy in China. National legislation mandates compensation for damage caused by protected wildlife, with implementation led by provincial governments in collaboration with insurance providers (Chen et al., 2016). Provinces including Qinghai, Gansu, Tibet Autonomous Region, Sichuan, and Xinjiang Autonomous Region have established compensation schemes covering livestock losses attributed to snow leopards.

In parallel, locally managed compensation mechanisms have emerged as complementary approaches. In Zaduo County, Qinghai Province, a community co-managed fund established in 2016 allows herders to define compensation standards and verification procedures, increasing transparency and local acceptance (Xiao et al., 2019). Such community models complement government compensation frameworks, combining robust public funding with participatory local engagement.

4.4 Community-based Conservation

Given that snow leopard habitats in China largely overlap with diverse ethnic and pastoralist communities practicing nomadic lifestyles, community involvement is fundamental to effective conservation (Hacker et al., 2020). Successful

coexistence requires coordinated efforts among scientists, government officials, and local residents to address HWC and promote sustainable livelihoods.

Qinghai: Sanjiangyuan National Park and “Valley of the Cats”

Sanjiangyuan National Park, piloted in 2015, is a flagship example of community-based conservation. It was the first National Park in China to award a franchise for community-based tourism, the “Valley of the Cats” initiative in Zaduo County, launched in 2018. This project leverages the high snow leopard encounter rate to attract eco-tourism, generating over USD 350,000 in revenue by 2024, all retained within the community. The income supports host families, public welfare projects, and snow leopard conservation, providing alternative livelihoods that reduce pressure on natural resources.

Sanjiangyuan National Park has also invested heavily in capacity building, employing over 17,000 pastoralists in ecological stewardship. Training programs cover environmental policies, camera trap monitoring, anti-poaching patrols, and biodiversity conservation (Xiao et al., 2019). By mid-2019, 264 local rangers operated across nine monitoring sites, covering about 7,000 km², producing valuable data on snow leopard populations and ecosystem health (Jia et al., 2020).

Tibet Autonomous Region: Empowering Indigenous Conservationists

In Tibet Autonomous Region, a 2016 project in Shenja County trained six local wildlife stewards in wildlife monitoring techniques, including camera trapping and GPS use. These pastoralists, drawing on indigenous knowledge, became key contributors to a 2,000 km² monitoring network supporting the Changtang Nature Reserve (Bian et al., 2023). Their activities extended to wildlife rescue, patrols, awareness campaigns, and anti-predator measures, demonstrating the critical role of local people in conservation success.

Xinjiang Autonomous Region: Building Community Networks

With support from the East Tien Shan State Forest Administration and NGOs, Wild Xinjiang established monitoring stations and forest stewardship offices in 2016 as part of efforts to create the Urumqi River Snow Leopard Reserve. A community-based network of 20 pastoralist households was formed, fostering local understanding and support for snow leopard conservation. This initiative reduced poaching incidents and laid the groundwork for future National Park development.

4.5 Public Engagement and the Role of Digital Media

Recent conservation efforts have increasingly incorporated digital platforms and technological innovation. Notably, the snow leopard has become an iconic and widely popular species online, raising broad public interest in its conservation and associated ecosystems. Public engagement initiatives using online payment platforms, social media, and artificial intelligence have expanded awareness of snow leopard conservation and generated financial support for field activities. While not substitutes for long-term institutional investment, these approaches have broadened participation and visibility of snow leopard conservation beyond traditional stakeholders.

Awareness Raising Programs

Alipay’s “Ant Forest”: Launched in 2016, this mobile program incentivizes users to reduce carbon emissions by awarding “green energy points” convertible into donations for conservation projects, including snow leopard habitats. The program combines environmental education with gamification, engaging millions and promoting behavioral change.

WeChat Mini-Programs: In collaboration with WWF, Tencent developed interactive programs for International Snow Leopard Day in 2020, featuring games and educational content that simulate snow leopard monitoring activities and promote ecological knowledge.

JD.com AI Challenge: In 2019, JD.com hosted an innovation challenge to develop AI tools for individual snow leopard identification, highlighting the importance of data processing in conservation and attracting youth participation.

Tencent Public Welfare: SSCC 2018 fundraising campaign for Sanjiangyuan National Park raised USD 82,000 to support HWC mitigation and community training, using storytelling and camera trap images to engage donors.

Sina Weibo Campaigns: The 2019 “Safeguard Snow Leopard Habitat Action” campaign aimed to raise USD 300,000 for anti-poaching, monitoring, and compensation programs, leveraging the platform’s massive user base to boost public awareness.

Overall, snow leopard conservation in China has shifted from isolated, site-based interventions toward more integrated, landscape-scale and community-engaged approaches. Strong legal protection, expansion of National Parks, structured compensation mechanisms, and growing community participation have created a robust foundation for conservation. However, ensuring effective coordination

across regions, sustaining long-term funding, and integrating climate adaptation into conservation planning remain key challenges.

5. Acknowledgements

We acknowledge the long-term efforts of national and provincial agencies in China in advancing snow leopard conservation, research, and monitoring. We also thank Chinese research institutions, conservation organizations, and practitioners whose work informed this synthesis. We are grateful to Snow Leopard Network China for support to snow leopard research and conservation, and to the IUCN SSC Cat Specialist Group for supporting this country status report series and the associated assessment process. We thank Dr. Ian Durbach for reviewing the statistical analyses, and Dr. Justine Shanti Alexander for coordinating this special issue and overseeing the review process.

We thank all co-authors' teams for providing information and support for this analysis. We extend our gratitude to the authors of the published studies from which snow leopard distribution data were extracted to build the MaxEnt model. We acknowledge the many researchers and practitioners whose work over past decades has contributed to the broader body of snow leopard knowledge considered in this analysis, including Som Ale, Madhu Chetri, Shoaib Hameed, Bing He, Rodney Jackson, Diqiang Li, Xuchang Liang, Sandro Lovari, Ming Ma, Kyle McCarthy, Thomas M. McCarthy, Charu Mishra, Owen Nevin, Kristin Nowell, Mikhail Yurievich Paltsyn, Marco Salvatori, George B. Schaller, Diwakar Sharma, Koustubh Sharma, Uttam Babu Shrestha, Dazhao Song, Ashok Subedi, Byron Weckworth, Feng Xu, Xin Yang, Meng Yao, and Yuguang Zhang.

6. Conflicts of Interest

The authors declare no known conflicts of interest.

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Snow Leopard (*Panthera uncia*) Status in China

Supplementary Materials

This supplementary material provides additional data and sources supporting the analyses presented in the main manuscript.

Tables

Table S1 lists the 66 snow leopard density surveys included in the population estimation analysis

Table S1. 66 snow leopard density surveys collected as final input data for the National Population Estimation

ID	Province	Survey Site	Year	Survey Method	Density Estimation Method	Survey Area
1	Qinghai	Sanjiangyuan - Angsai	2018–2019	CT	MS SECR	1,470
2	Qinghai	Sanjiangyuan - Diqing	2015	CT	MS SECR	818
3	Qinghai	Sanjiangyuan - Yunta	2015	CT	MS SECR	80
4	Qinghai	Sanjiangyuan - Nianbao Yuzhe	2020–2021	CT	MS SECR	30
5	Qinghai	Sanjiangyuan - Dongge Cuona Lake	2019–2020	CT	MS SECR	883
6	Qinghai	Sanjiangyuan - Qumalai	2018–2019	CT	MS SECR	1,375
7	Qinghai	Sanjiangyuan - Ganglong Township	2021	CT	MS SECR	862
8	Qinghai	Sanjiangyuan - Anme Machin	2021	CT	MS SECR	1,669
9	Qinghai	Sanjiangyuan - Hebei Township	2021	CT	MS SECR	624
10	Qinghai	Sanjiangyuan - Suojia	2020–2021	CT	MS SECR	643
11	Qinghai	Sanjiangyuan - Chengduo (CD0114)	2018–2019	CT	MS SECR	432
12	Qinghai	Sanjiangyuan - Chengduo (CD1530)	2018–2019	CT	MS SECR	519
13	Qinghai	Sanjiangyuan - Yage Valley	2014	CT	CE	40
14	Qinghai	Zhiyu Village, Gouli, Dulan County, Haixi Prefecture	2008	SS, IT	CE	1,900
15	Qinghai	Gouli region, Dulan County, Haixi Prefecture	2005–2007	CT	CE	300
16	Qinghai	Huangnan Prefecture	2023–2024	CT	SECR	1,150
17	Qinghai	Qilian Mountain National Park (QMNP) (Qinghai) (high density)	2017–2021	CT	MS SECR	6,100
18	Qinghai	QMNP (Qinghai) (medium density)	2017–2021	CT	MS SECR	
19	Qinghai	QMNP (Qinghai) - Youhulu	2020–2021	CT	SECR	400
20	Gansu	QMNP (Jiuquan) (high density)	2022–2023	CT	MS SECR	4,150
21	Gansu	QMNP (Jiuquan) (medium density)	2022–2023	CT	MS SECR	
22	Gansu	QMNP (Jiuquan) - Shulenanshan Mountain, Yanchiwan	2015–2016	CT	SECR	400
23	Gansu	QMNP (Zhangye) - Machang	2019	CT	SECR	650

ID	Province	Survey Site	Year	Survey Method	Density Estimation Method	Survey Area
24	Gansu	QMNP (Zhangye) - Qifeng	2013–2014	CT	SECR	375
25	Xinjiang	Bortala Alataw Mountain - Northern part	2023–2024	CT	SECR	425
26	Xinjiang	Bortala Alataw Mountain - Southern part	2023–2024	CT	SECR	575
27	Xinjiang	Western Tianshan Nature Reserve	2020–2021	CT	SECR	500
28	Xinjiang	Tianshan	2013–2015	PB	PB	1,643
29	Xinjiang	Tomur Nature Reserve	2020–2021	CT	SECR	1,000
30	Sichuan	Gongga Mountain	2016–2017	CT	CE	750
31	Tibet	Mayue Township, Shenzha County, Naqu	2018	CT	SECR	1,950
32	Tibet	Nima Township, Nima County, Naqu	2021–2023	CT	CE	770
33	Tibet	Deqing Township, Bange County, Naqu	2021–2023	CT	CE	320
34	Tibet	Baling Township, Shuanghu County, Naqu	2021–2023	CT	CE	603
35	Tibet	Maqu Township, Anduo County, Naqu	2021–2023	CT	CE	878
36	Tibet	Chadang Township, Nierong County, Naqu	2021–2023	CT	CE	543
37	Tibet	Gongri Township, Baqing County, Naqu	2021–2023	CT	CE	398
38	Tibet	Rongbu Township, Suo County, Naqu	2021–2023	CT	CE	404
39	Tibet	Niwu Township, Jiali County, Naqu	2021–2023	CT	CE	333
40	Tibet	Xiangmao Township, Seni County, Naqu	2021–2023	CT	CE	376
41	Tibet	Yangxiu Township, Biru County, Naqu	2021–2023	CT	CE	278
42	Tibet	Qomolangma National Nature Reserve (Dingriand Dingjie County)	2014–2020	CT	SECR	1,400
43	Tibet	Qomolangma National Nature Reserve (Nielamu County)	2014–2020	CT	SECR	525
44	Tibet	Qomolangma National Nature Reserve (Jilong Section)	2023–2024	CT	SECR	4,000
45	Tibet	Bujia Mountain (Dingqing County)	2020–2021	CT	SECR	1,275
46	Tibet	Dingqing County, Changdu	2021–2022	CT	CE	2,091
47	Tibet	Nailang Valley, Duilongdeqing District, Lhasa	2024	CT	SECR	54
48	Sichuan	Qionglai Mountains	2020	CT	SECR	1,600
49	Xinjiang	Altun Mountains - Altun	2024	CT	SECR	1,500
50	Xinjiang	Altun Mountains - Qiemo	2024	CT	SECR	1,500
51	Gansu	QMNP (Jiuquan) - Danghenanshan Mountain, Yanchiwan	2017-2018	CT	MS SECR	550
52	Gansu	QMNP (Jiuquan) - Yemananshan Mountain, Yanchiwan	2017	CT	MS SECR	625
53	Gansu	QMNP (Jiuquan) - Shulenanshan Mountain, Yanchiwan	2016-2017	CT	MS SECR	325
54	Gansu	QMNP (Zhangye) - Longchanghe	2018	CT	MS SECR	450
55	Gansu	QMNP (Zhangye) - Qifeng	2017	CT	MS SECR	450
56	Gansu	QMNP (Zhangye) - Sidalong	2017	CT	MS SECR	325
57	Xinjiang	Eastern Tianshan - Banfanggou	2022	CT	MS SECR	325
58	Xinjiang	Eastern Tianshan - Hami	2021-2022	CT	MS SECR	850
59	Xinjiang	Eastern Tianshan - Hutubi	2021-2022	CT	MS SECR	250
60	Xinjiang	Eastern Tianshan - Jimusaer	2021-2022	CT	MS SECR	350
61	Xinjiang	Eastern Tianshan - Mulei	2021-2022	CT	MS SECR	800

ID	Province	Survey Site	Year	Survey Method	Density Estimation Method	Survey Area
62	Xinjiang	Eastern Tianshan - Miquan	2021-2022	CT	MS SECR	275
63	Xinjiang	Eastern Tianshan - Qitai	2021-2022	CT	MS SECR	375
64	Xinjiang	Eastern Tianshan - Shawan	2021-2022	CT	MS SECR	150
65	Xinjiang	Eastern Tianshan - Urumqi Nanshan	2021-2022	CT	MS SECR	275
66	Xinjiang	Eastern Tianshan - Wusu	2019	CT	MS SECR	225

Note: For survey method, CT = Camera trapping, PB = Prey Biomass, SS = Sign Survey, IT = Interview. For density estimation method, MS SECR = Multi-Session SECR, PB = Prey Biomass, CE = Crude estimate of dividing number of snow leopard individuals by the survey area. For detailed data sources of each survey, please see data sources below.

To assess the influence of pre-2015 surveys, we performed population estimation without excluding these early datasets. Table S2 presents the average density of each stratum and the total estimated snow leopard population size across the ‘Extant’ range in China under the scenario retaining early survey data. The total population estimate is 7,259 when outliers are retained, and 6,023 when outliers are excluded.

Table S2. The density estimation in each stratum and the overall population estimate with early surveys retained.

Data Used (No. surveys)	Rank Strata	Density (ind/100 km ²)	Total Area (km ²)	Abundance			
				Mean	SE	LCL	UCL
All survey data (66)	Medium (0.75–0.9)	1.20	291,085	3,486	914	1,695	5,277
	High (0.9–1)	1.03	365,291	3,773	389	3,011	4,535
	Total		656,376	7,259		4,706	9,811
All survey data excluding outliers (64)	Medium (0.75–0.9)	0.77	291,085	2,251	376	1,514	2,987
	High (0.9–1)	1.03	365,291	3,773	389	3,011	4,535
	Total		656,376	6,023		4,525	7,522

To assess the effect of outliers, we conducted population estimation while retaining outlier density surveys. Table S3 summarizes the average density of each stratum and the overall population size estimation of snow leopards in China, which amounts to 6,585 (4,317–8,854).

Table S3. The density estimation in each stratum and the overall population estimate with outliers retained.

Data Used (No. surveys)	Rank Strata	Density (ind/100 km ²)	Total Area (km ²)	Abundance			
				Mean	SE	LCL	UCL
All survey data after 2015 (61)	Medium (0.75–0.9)	0.96	291,085	2,800	754	1,322	4,278
	High (0.9–1)	1.04	365,291	3,785	403	2,995	4,575
	Total		656,376	6,585		4,317	8,854

Among the 61 surveys included, 12 did not report density estimates. For these sites, we applied a crude density calculation as the number of adult snow leopard individuals divided by the reported survey area. To evaluate the influence of these crude density estimates, we additionally conducted a sensitivity analysis excluding the 12 surveys. This subset retained only surveys with SECR-derived density estimates and removed outliers via the interquartile range (IQR) method. Table S4 shows the average density of each stratum and the overall estimated snow leopard population size in China using only SECR-based survey data, which amounts to 5,196 (4,003–6,389), differing by only 0.7% from the main result.

Table S4. The density estimation in each stratum and the overall population estimate with crude density estimates excluded.

Data Used (No. surveys)	Rank Strata	Density (ind/100 km ²)	Total Area (km ²)	Abundance			
				Mean	SE	LCL	UCL
SECR density surveys, outliers excluded (45)	Medium (0.75–0.9)	0.61	291,085	1,763	291	1,193	2,332
	High (0.9–1)	0.94	365,291	3,434	318	2,811	4,057
	Total		656,376	5,196		4,003	6,389

We also assessed the sensitivity of population estimates to the classification thresholds for medium and high habitat quality strata, varying them from 0.8 to 0.95 in increments of 0.05. This analysis yielded estimates ranging from 5,232 to 5,433 (Table S5), representing a variation of less than 3.8%.

Table S5. The density and population estimation using different stratum threshold.

Threshold used		0.8	0.85	0.9	0.95
Area (km ²)	Medium stratum	91,736	160,270	291,086	455,008
	High stratum	564,640	496,106	365,291	201,369
Density (ind/100 km ²)	Medium stratum	0.64	0.65	0.63	0.79
	High stratum	0.86	0.87	0.93	0.91
Population estimate		5,416	5,352	5,232	5,433

Figures

Complementing Table S2, Figure S1 presents descriptive distributions for the dataset including pre-2015 surveys. The relationship between habitat rank values and density estimates showed a generally positive trend, both when including outliers (Spearman’s $\rho = 0.194$, $p = 0.118$, Figure S1a) and excluding outliers (Spearman’s $\rho = 0.276$, $p = 0.027$, Figure S1c). Data distribution within each stratum is illustrated in Figure S1b (with outliers) and Figure S1d (without outliers).

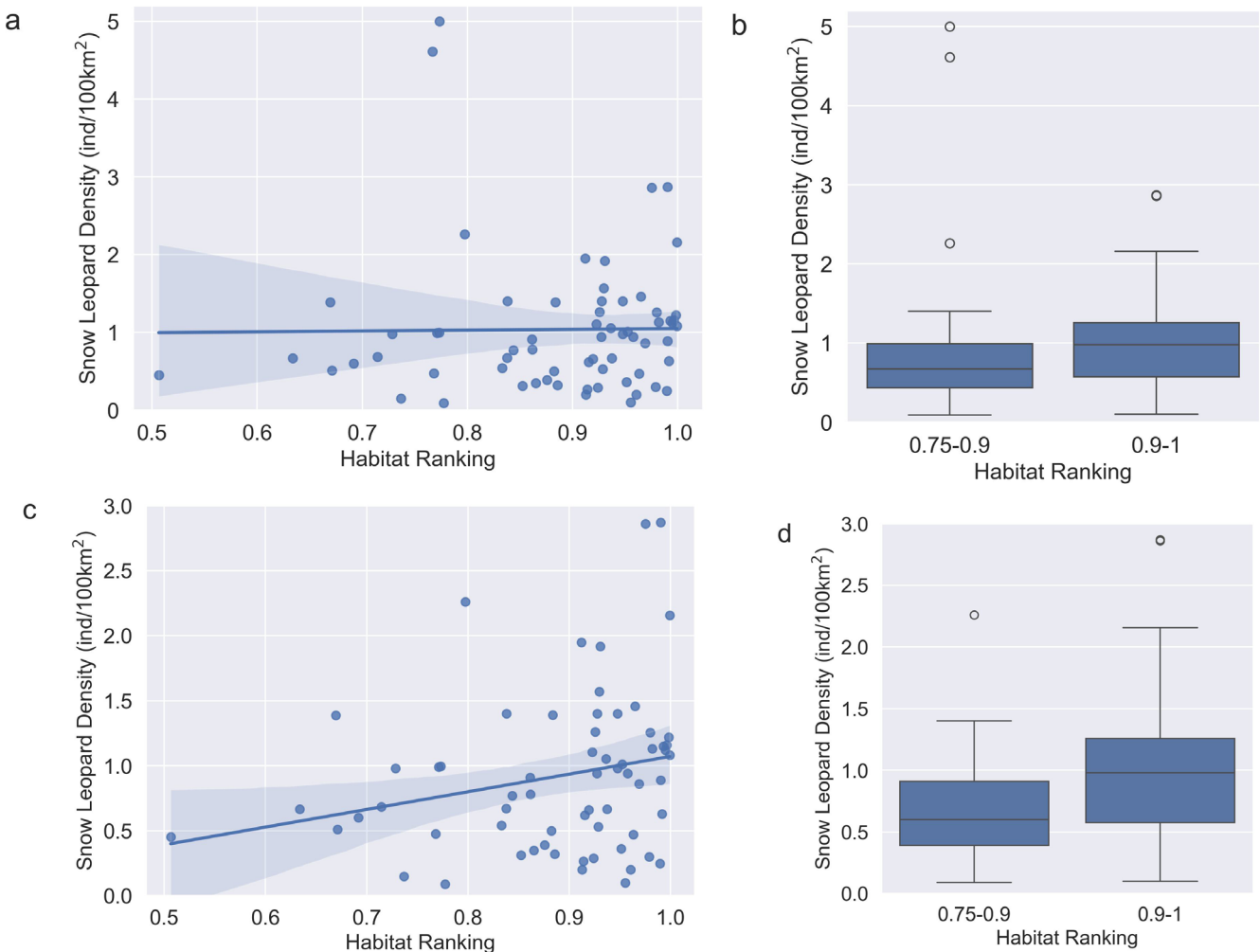


Figure S1. (a) (b) show the scenario including surveys before 2015 with outliers, while (c)-(d) show the scenario including surveys before 2015 without outliers. (a) and (c) depict the relationship between snow leopard habitat rank values and density estimates. (b) and (d) display boxplots showing the median (line), first and third quartiles (box), and range of typical data values within 1.5×IQR (whiskers) of density estimates within each habitat stratum.

Complementing Table S3, Figure S2 presents descriptive distributions for the dataset retaining outliers. The relationship between habitat rank values and density estimates exhibited a generally positive relationship (Spearman's $\rho = 0.289$, $p = 0.024$, Figure S2a). Figure S2b illustrates the data distribution within each stratum.

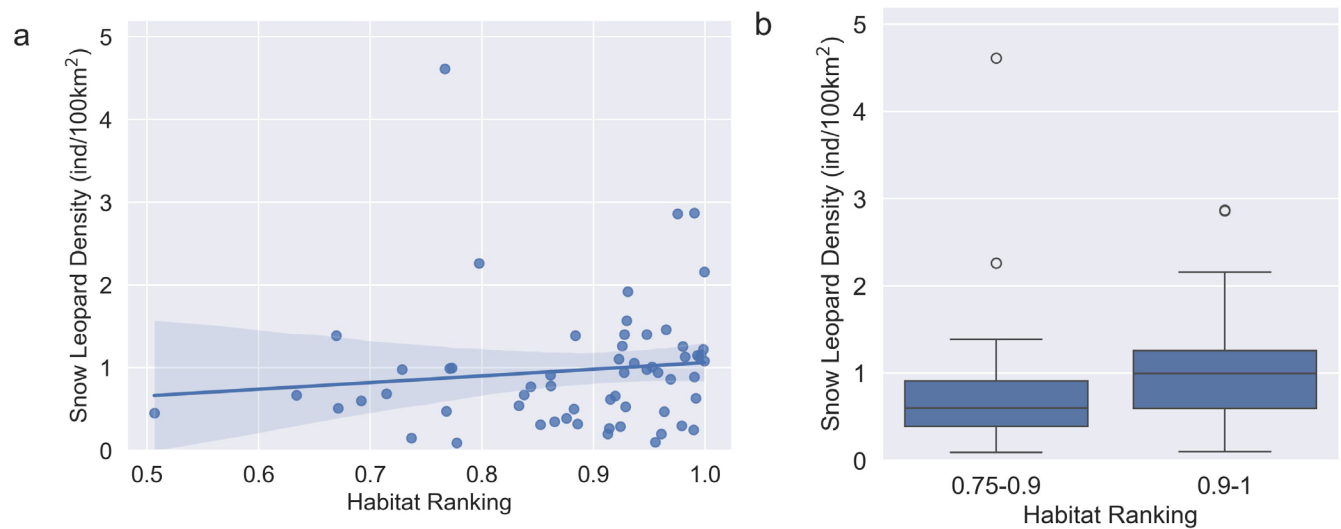


Figure S2. (a) (b) show the scenario with outliers retained.
(a) Relationship between snow leopard habitat rank values and density estimates.
(b) Boxplot showing the median (the line), the first and third quartiles (the box), and the range of typical data values within 1.5×IQR (the whiskers) of the density estimates within each habitat stratum.

Complementing Table S4, Figure S3 shows descriptive distributions for the dataset that excludes crude density estimates and the associated outliers. Habitat rank values and density estimates showed a significant positive correlation (Spearman's $\rho = 0.383$, $p = 0.009$; Figure S3a). Figure S3b illustrates the data distribution within each stratum.

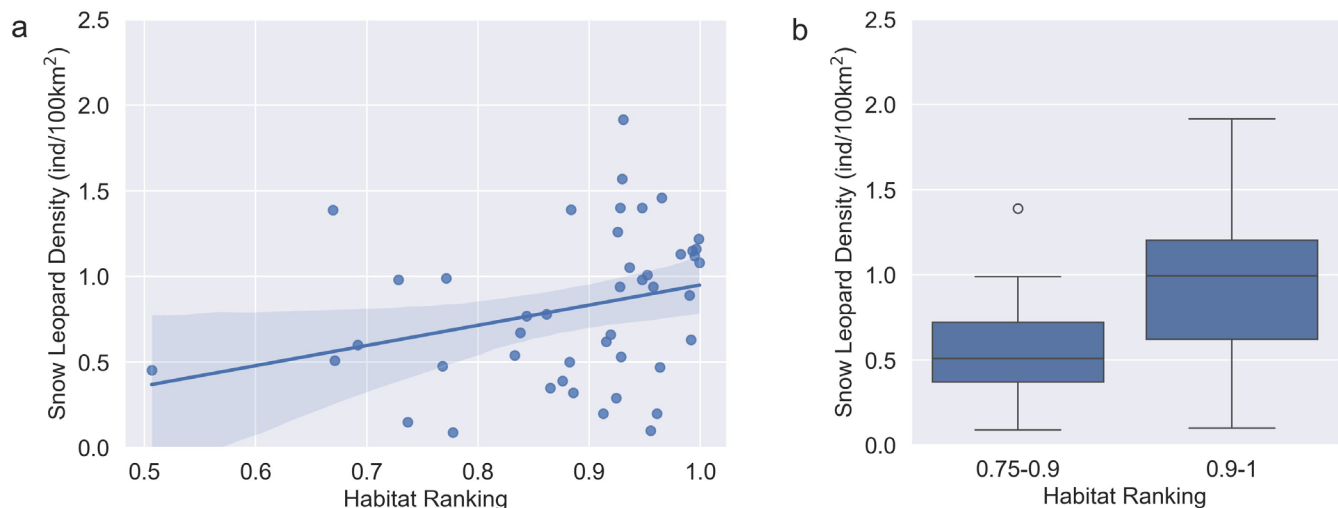


Figure S3 (a)-(b) show the scenario with crude density estimates excluded.
(a) Relationship between snow leopard habitat rank values and density estimates.
(b) Boxplot showing the median (the line), the first and third quartiles (the box), and the range of typical data values within 1.5×IQR (the whiskers) of the density estimates within each habitat stratum.

Data Sources

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