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SPECIAL ISSUE | THE STATUS OF SNOW LEOPARDS ACROSS HIGH ASIA

Snow Leopard (*Panthera uncia*) Status in Mongolia

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1. Distribution

Mongolia supports the north-easternmost population of snow leopards (*Panthera uncia*). The species' distribution in the country is closely associated with suitable mountainous habitat (Bayandonoi et al. 2021a). Snow leopards primarily occur in the Mongolian Altai, Gobi Altai, and Khangai mountain ranges, as well as in the Sayan Mountains along the border with the Russian Federation (Bayandonoi et al. 2021a). However, snow leopards are also known to use non-mountainous terrain, including steppe habitats, for movement and dispersal between mountain ranges (Johansson et al. 2024).

Current understanding of snow leopard distribution in Mongolia is based on a rigorous occupancy modelling approach that incorporated both presence and absence data (Bayandonoi et al. 2021a). This represents a substantial improvement over earlier assessments that relied on expert opinion or presence-only models. The assessment was based on sign-based occupancy surveys covering 406,800 km² of potential habitat and indicated that previous range estimates both omitted areas currently used by snow leopards and included areas with a low probability of use (Bayandonoi et al. 2021a). For example, the predicted snow leopard range in the Khangai Mountains (Central Mongolia) is now larger than previously recognised, although estimated densities in this region remain very low.

The most recent estimate of potential snow leopard range in Mongolia is 326,617 km² (Figure 1), substantially

exceeding earlier estimates of 90,000–130,000 km² based on expert opinion (Mallon 1984; Schaller et al. 1994; McCarthy 2000). Within this area, snow leopard distribution is discontinuous, with populations fragmented in several regions. Fragmentation is particularly evident in the south-eastern Altai Mountains and in isolated pockets of the Khangai Mountains.

Connectivity between the Altai and Khangai ranges is constrained by extensive steppe areas, which may pose challenges for movement, particularly as these landscapes undergo increasing development, including the expansion of infrastructure such as roads and fencing. In the South Gobi, snow leopard habitat is characterised by isolated mountain massifs that are predicted to support relatively high densities. In addition, some areas previously considered unsuitable, such as the Ulaan Taiga and Khoridol Saridag Mountains, are now known to be used by snow leopards.

Occasional detections beyond the predicted mountainous distribution illustrate the species' capacity for long-distance movement. A snow leopard recorded in Ikh Nart Nature Reserve, approximately 266 km from the nearest known population, represents one of the easternmost records for the species (Wingard et al. 2023). Recent GPS-collar data further demonstrate that dispersing subadult snow leopards are capable of traversing extensive areas of steppe and desert during exploratory movements, indicating that such landscapes do not represent absolute barriers to movement (Johansson et al. 2024).

Several important transboundary snow leopard populations occur along the Mongolia–Russia border. Key transboundary areas include the Altai Tavan Bogd Mountains in Mongolia and the Southern Altai Ridge in Russia; Tsagaan Shuvuut in Mongolia and the Tsagan-Shibetu and Shapshalsky ranges in Russia; the Siilkhem Mountains in Mongolia and the Sailugem–Chikhachev mountain ridges in Russia; and Ikh Soyon in Mongolia and the Eastern Sayan Range in Russia. Together, these landscapes maintain critical connectivity between Mongolian and Russian snow leopard populations (Bayandonoi et al. 2021a).

Along the Mongolia–China border, additional transboundary populations occur in the Chigertei Ridge and the Baitag Bogd–Takhiin Shar Nuruu–Khavtaga Mountain complex, which are bisected by the international boundary between the two countries (Bayandonoi et al. 2021a). Although individual snow leopards can move across extensive steppe habitats, population-level genetic analyses indicate limited contemporary gene flow between Mongolia and north-western China. Movement data further suggest that border fencing constrains cross-border dispersal, resulting in weak functional connectivity across

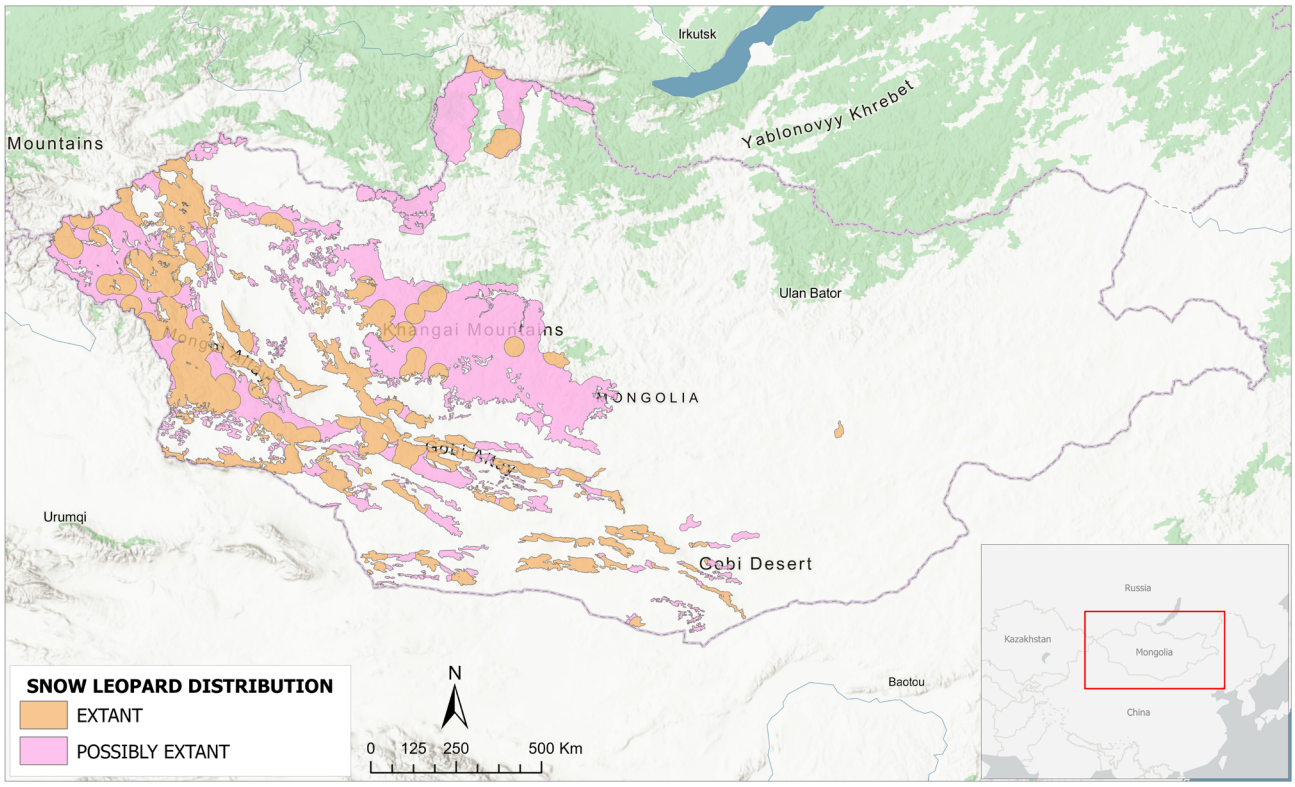

Figure 1. *Distribution of the snow leopard (Panthera uncia) in Mongolia based on IUCN Red List mapping criteria. The shaded area (orange is classified as extant and pink is classified as possibly extant) represents the distribution within the country. The map is derived from Bayandonoi et al. (2021), which applied probabilistic occupancy modelling to assess snow leopard distribution across Mongolia.*

the southern Gobi (Hacker et al. 2022; Johansson et al. 2024).

The updated IUCN Red List distribution map for snow leopards in Mongolia (Figure 1) is primarily based on probabilistic occupancy modelling combined with records of territorial signs. Figure 1 was adapted from Bayandonoi et al. (2021a, 2021b) to align with IUCN Red List mapping standards. The following criteria were applied during this adaptation:

> Areas with a low probability of snow leopard occurrence were excluded from the potential range. Specifically, sampling units of 20 × 20 km with an estimated probability of presence below 2% were removed, effectively excluding much of eastern Mongolia, flat depressions, extensive steppe regions, and the forested north. Terrain characteristics were further refined by excluding steppe and valley areas with slopes below 5°, which are generally unsuitable as snow leopard territories. High-altitude mountain steppe was retained, while low-slope areas were considered occasional movement corridors rather than resident habitat. Non-habitat features, including lakes and sand dunes, were also excluded as unsuitable for snow leopards.
>
> Areas were classified as *Extant* when located within 20 km of confirmed snow leopard territorial signs (pugmarks, scats, scrapes, or camera-trap detections) recorded between 2015 and 2024. Remaining areas that met the above criteria, had an estimated presence probability greater than 2%, but lacked recent evidence of residency or were considered non-resident based on opportunistic detections, were classified as *Possibly Extant*.

Several environmental factors influence snow leopard distribution across Mongolia. Terrain ruggedness is a key determinant, with areas of higher ruggedness more likely to be used by snow leopards (Bayandonoi et al. 2021a). Occupancy analyses indicate a preference for intermediate elevations, lower vegetation indices, and areas with limited forest cover (Bayandonoi et al. 2021a). In addition, the availability of primary prey species, particularly Siberian ibex (*Capra sibirica*) and argali (*Ovis ammon*), plays an important role in shaping snow leopard distribution patterns (Johansson et al. 2022).

2. Population

The most recent estimate of the snow leopard population in Mongolia is 953 adult individuals (95% confidence interval: 806–1,127), based on a nationwide assessment conducted between 2017 and 2020 (Bayandonoi et al. 2021b). This assessment combined occupancy surveys with spatial capture–recapture analyses derived from camera-trap data and follows the methodological framework outlined under the Population Assessment of the World's Snow Leopards (PAWS) guidelines (Sharma et al. 2019). Earlier population estimates for Mongolia have varied widely, reflecting the inherent challenges of monitoring an elusive species across a vast, remote, and topographically complex landscape. Previous estimates include approximately 700 individuals (Bold & Dorjzundui 1976), 557–1,127 individuals (McCarthy & Mallon 2016), c. 1,000 individuals (Munkhtsog et al. 2016), and 1,500–1,700 individuals (Schaller et al. 1994).

The current estimate refers specifically to adult snow leopards; inclusion of dependent cubs would increase the total population size. Mongolia supports the second largest snow leopard population globally, underscoring the country's importance for the long-term conservation of the species (Munkhtsog et al. 2016). The population also plays an important role in maintaining regional connectivity and gene flow, particularly with populations in the Russian Federation.

Snow leopard density varies across Mongolia's three occupancy strata (Bayandonoi et al. 2021a, b), with an overall mean density estimated at 0.31 individuals per 100 km². Areas classified as high density support a mean density of 0.61 individuals per 100 km² across 48,290 km², medium-density areas support a mean density of 0.35 individuals per 100 km² across 153,840 km², and low-density areas support a mean density of 0.09 individuals per 100 km² across 124,487 km². Spatial variation in density is influenced by a combination of habitat characteristics, prey availability, and broader landscape context.

Long-term monitoring in the Tost Mountains indicates that, although local population sizes may appear relatively stable over time, snow leopard populations are highly dynamic. In particular, high rates of immigration and emigration, especially among dispersing subadult individuals, contribute to population turnover and underline the importance of connectivity at the landscape scale (Sharma et al. 2014).

3. Threats

Snow leopards in Mongolia face multiple, interacting threats, largely driven by human activities and environmental change. These include habitat loss and degradation, depletion of the wild prey base, retaliatory killing following livestock depredation, illegal hunting

and trade, infrastructure development and mining, and the emerging impacts of climate change (Johansson et al. 2015; Sharma et al. 2014; Lukarevskiy et al. 2020; Alexander et al. 2021; Munkhtsog et al. 2024).

Habitat degradation and prey depletion

Habitat loss and degradation represent major threats to snow leopards in Mongolia, primarily driven by overgrazing associated with rapidly increasing livestock numbers (Munkhtsog et al. 2024). Since the early 1990s, livestock numbers have risen sharply, from approximately 25 million head in 1990 to over 71 million in 2022 (National Statistics Office of Mongolia, 2022). This expansion has led to widespread pasture degradation and increasing encroachment of livestock into snow leopard habitats, intensifying competition for forage and water resources (Berger et al. 2013; Munkhtsog et al. 2024).

High livestock presence is predicted to displace mountain ungulates, which tend to avoid heavily grazed areas, resulting in reduced availability of key prey species for snow leopards (Johansson et al. 2015). In addition, close spatial overlap between livestock and wild ungulates increases the risk of disease transmission. Mongolia's pastoral systems are characterised by the widespread presence of livestock-associated zoonotic pathogens, including brucellosis, anthrax, tuberculosis, and parasitic infections, which may pose indirect risks to wildlife populations (Tsogtbayar et al. 2025)

Wild prey depletion is further exacerbated by ongoing illegal and subsistence hunting of wild ungulates, which remains a concern in parts of Mongolia despite legal protections (Wingard & Zahler 2006; Munkhtsog et al. 2024). Local reductions in populations of Siberian ibex (*Capra sibirica*) and argali (*Ovis ammon*) may reduce natural prey availability for snow leopards and increase reliance on domestic livestock, thereby reinforcing negative interactions with herders and elevating the risk of retaliatory killing.

Retaliatory killing and negative human–carnivore interactions

Negative interactions between people and large carnivores remain a significant threat to snow leopards in Mongolia. Retaliatory killing following livestock depredation has been widely documented as an important source of snow leopard mortality across the country (Johansson et al. 2015; Alexander et al. 2021; Mijiddorj et al. 2018).

Snow leopards prey on a range of domestic animals, including sheep (*Ovis aries*), goats (*Capra hircus*), yaks (*Bos grunniens*), horses (*Equus ferus caballus*), and camels (*Camelus bactrianus*). Depredation occurs both on open pastures and at night-time corrals, with occasional multiple animals killed in single events (Johansson et al. 2015; Mijiddorj et al. 2018). For example, in parts of the Gobi, livestock depredation frequently involves goats, which are of high economic importance due to cashmere production, as well as young, free-ranging horses during their first months of life (Mijiddorj et al. 2018). Losses of horses may be perceived as particularly severe given their cultural significance in Mongolia.

Grey wolves (*Canis lupus*) account for a substantial proportion of livestock losses in many parts of Mongolia, and cumulative losses attributed to several carnivore species can intensify negative perceptions toward predators (Mijiddorj et al. 2018; Johansson et al. 2015). Retaliatory responses are not always selective, and snow leopards may be targeted or incidentally killed even when they are not responsible for specific depredation events.

Patterns of livestock depredation and associated negative interactions are shaped by ecological conditions and the spatial and temporal overlap between livestock and carnivores.

In Mongolia's open rangeland systems, depredation risk is influenced by ongoing changes in herding practices. Mijiddorj et al. (2018) report that increasing herd sizes, reduced labour availability, and shifts toward more mobile herding using motorcycles have altered livestock supervision patterns, with animals often ranging over larger areas and remaining unattended for longer periods. Seasonal movements, topography, and local variation in wild prey availability further influence where and when depredation events occur, contributing to marked spatial and temporal variability in conflict intensity (Johansson et al. 2015; Mijiddorj et al. 2018).

Illegal hunting and trade

Illegal hunting and trade continue to pose a direct threat to snow leopards in Mongolia (Munkhtsog et al. 2024). The snow leopard is fully protected under Mongolian law, including the Law on Fauna and the Criminal Code, which prohibit the hunting, possession, transport, and trade of the species and prescribe criminal penalties for violations. Mongolia is also a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), under which the snow leopard is listed in Appendix I, prohibiting all international commercial trade.

Despite this legal protection, illegal killing persists. Snow leopards are primarily targeted for their skins, which are valued for luxury fur products, and for bones and other body parts that may be used as substitutes for tiger (*Panthera tigris*) products in traditional medicine markets. Recent confiscations of snow leopard skins at Mongolian

customs demonstrate that illegal trade remains active and that both domestic and cross-border trade routes continue to operate. Law enforcement data indicate eight confirmed cases of illegal snow leopard hunting and trade between 2014 and 2018, increasing to 18 cases between 2019 and 2023, indicating that illegal exploitation remains an ongoing concern (WWF-Mongolia 2024). In Mongolia, snow leopards killed in conflict situations may subsequently be sold or traded locally, linking retaliatory killing with illegal trade.

Infrastructure development and mining

Infrastructure development and mining represent increasing pressures on snow leopard habitats in Mongolia. Mongolia's economy has grown steadily in recent years, with real GDP growth of approximately 5% in 2024 and projected growth of around 6% in 2025, driven largely by mineral extraction and associated transport and infrastructure development (World Bank 2024). Roads, railways, border fencing, pipelines, and associated infrastructure can act as physical or behavioural barriers to movement, fragment habitats, and increase mortality risk for snow leopards and their prey (Zahler & Victurine 2024). These impacts are of particular concern in Mongolia, where snow leopard habitat often consists of isolated mountain massifs separated by steppe or desert landscapes. Movement between neighbouring mountain ranges is therefore important for dispersal and maintaining functional connectivity (Johansson et al. 2024). Linear infrastructure constructed across lowland areas may reduce landscape permeability and constrain movements between otherwise suitable habitats (Zahler & Victurine 2024; Gregory et al. 2025). Infrastructure development can also generate indirect impacts. Improved access to remote areas may increase human presence and disturbance and facilitate illegal hunting of both snow leopards and wild ungulates (Zahler & Victurine 2024).

Mining development can pose additional pressures on snow leopard habitats through direct and indirect pathways. Mongolia's mining sector is dominated by coal and copper extraction, with gold also contributing to national production, and has been a major driver of recent economic growth (World Bank 2024). Mining operations may result in habitat loss, degradation of water sources, increased traffic and noise, and changes in land use around key valleys and water points. In arid and semi-arid regions of Mongolia, where water availability is naturally limited, such activities may place additional pressure on areas also used by wildlife. Although the direct population-level impacts of mining on snow leopards and their habitats remain poorly studied, mining-related activities and associated infrastructure increasingly overlap with known snow leopard range.

Climate Change

Climate change represents an emerging pressure on snow leopard landscapes in Mongolia. Mean air temperatures in Mongolia have increased by approximately 1.7–2.0 °C since the mid-20th century, exceeding the global average, and this warming has been accompanied by increasing aridity and more frequent drought events (Nandintsetseg et al. 2021). Mongolia's National Adaptation Plan identifies pastures, water resources, and ecosystems as highly vulnerable to climate change, with increasing risks from drought, *dzud*, and heat extremes projected through mid-century (Government of Mongolia 2024). *Dzud* events, driven by the interaction of summer drought and severe winter conditions, have increased in frequency and have caused substantial livestock mortality, with indirect implications for grazing pressure and habitat condition (Nandintsetseg et al. 2020). Climate change is also expected to affect pastoral livelihoods and mobility, altering seasonal grazing patterns and migration routes, with knock-on effects for land use and habitat conditions within snow leopard range.

Although direct impacts of climate change on snow leopard ecology have not been quantified, climate-driven changes in vegetation productivity, water availability, and human land use are likely to influence prey distribution and livestock movements. Current evidence therefore suggests that climate change affects snow leopards primarily through indirect, ecosystem-mediated pathways.

4. Conservation

Conservation of the snow leopard in Mongolia integrates national legislation, protected area management, community-based initiatives, scientific research, and intergovernmental cooperation (Munkhtsog et al. 2024). Snow leopards are legally protected under Mongolian law, including the Law on Fauna and the Criminal Code, which prohibit hunting, possession, and trade. At the national level, the species is classified as *Very Rare*, affording it the highest legal protection status.

The Government of Mongolia has established an extensive protected area network that plays a central role in snow leopard conservation. As of 2025, approximately 28.1% of snow leopard habitat lies within the State Protected Areas Network, encompassing 52 protected areas that include key snow leopard landscapes. In addition, numerous local protected areas designated at the aimag and soum levels occur within the species' distribution. While these local protected areas are important in terms of spatial coverage, they often lack dedicated budgets, permanent staff, and management plans, and conservation actions are therefore frequently limited in practice despite formal designation.

Snow leopard conservation is guided by a series of national policies and strategies, including the National Biodiversity Conservation Policy (1996; revised 2015), the Snow Leopard Conservation Management Plan (1999), the Snow Leopard Conservation Policy (2005), the National Program on Conservation of Very Rare and Rare Wildlife Species (2011), the Mongolia National Snow Leopard and Ecosystem Protection Priorities (2013), and the National Programme for Biodiversity Conservation (2015). Mongolia completed a reassessment of the national Red List status of mammals in 2025, in which the snow leopard was classified as Endangered (Alexander et al. 2025).

Implementation and enforcement of snow leopard conservation measures involve multiple government agencies. The Ministry of Environment and Climate Change oversees national policy and protected area management through its Protected Areas Department and the Natural Resource Management Department. At the local level, aimag and soum government (including environmental agencies) are responsible for local conservation action outside protected areas. In addition, the Ecological Police, state environmental inspectors, the General Authority for Border Protection, and the General Customs Administration of Mongolia plays a role in addressing wildlife crime, including illegal hunting and trade of snow leopards and their prey. Coordination among actors is critical for effective law enforcement across Mongolia's large and remote landscapes.

Engagement of pastoral communities is a core component of snow leopard conservation in Mongolia. Community-based programmes aim to reduce negative human–wildlife interactions and increase local support for conservation. These include livestock insurance schemes that compensate herders for losses attributed to snow leopard predation (Alexander et al. 2021) and the construction of improved night-time corrals to reduce livestock depredation (Samelius et al. 2021). Broader community-based natural resource management initiatives also seek to support livelihoods and promote conservation-compatible land use through alternative income generation, value-added livestock production, and community-managed tourism.

Scientific research and monitoring provide an essential foundation for conservation planning. Long-term ecological studies in the Tost Mountains of southern Mongolia have generated detailed information on snow leopard home range size, reproduction, dispersal, survival, and population dynamics, highlighting the importance of immigration and emigration processes for local population stability (Sharma et al. 2014; Johansson et al. 2015; Johansson et al. 2022). At the national scale, repeated snow leopard population assessments using sign-based occupancy surveys and camera trapping have improved estimates of abundance and distribution and support adaptive management (Bayandonoi et al. 2021a, b).

Transboundary cooperation is also important for snow leopard conservation, given the species' distribution along international borders. Mongolia collaborates with neighbouring countries, particularly the Russian Federation and China, through bilateral agreements and joint initiatives. Transboundary protected areas linking northern Mongolia and southern Siberia facilitate coordination in monitoring, research, and habitat protection for shared snow leopard populations (Munkhtsog et al. 2024).

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6. Conflicts of Interest

The authors declare no known conflicts of interest.

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