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OVERVIEW REPORT ON THE STATUS AND CONSERVATION OF THE PERSIAN LEOPARD ACROSS ITS RANGE STATES

Summary: The overview report was prepared for the CMS Secretariat by a group of experts, led by the IUCN Cat Specialist Group co-chairs. This work was funded in the framework of the cooperation between the CMS Secretariat and the International Academy for Nature Conservation of the German Federal Agency for Nature Conservation (BfN INA) by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The views expressed herein are those of the authors and do not necessarily reflect official opinions of the involved institutions. A revision of the document was prepared to correctly refer to the authors of the document.

Action requested: Take note of the report.

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1. Summary of the status, population trends, threats and conservation needs of the Persian Leopard across its range

The Persian Leopard *Panthera pardus tulliana* (Kitchener et al. 2017) is a subspecies of leopard from Central and South-West Asia (Bleyhl et al. 2022, Rosen & Mengüllüoğlu 2022). In the IUCN Red List assessment, the Persian Leopard was listed as Endangered (EN C2a(i); Khorozyan 2008). At present, this status of "Endangered" is still considered appropriate for the Persian Leopard. In some areas within its range, however, the Persian Leopard's local status is very critical due to its small population size and high level of exposure to imminent threats such as habitat fragmentation and poaching (Bleyhl et al. 2017, 2022), e.g. in the Caucasus the Persian Leopard should presumably be listed as Critically Endangered under C2a(i);D (Khorozyan 2010). In Iran, it has been listed nationally as Endangered under C2a(i) (Yusefi et al. 2019).


A Persian Leopard captured on camera in the Alborz Kopet-Dagh region © Team Bars Turkmenistan.

As the distribution range of the Persian Leopard has substantially reduced (Jacobson et al. 2016) and now consists of small, isolated populations (Figure 1.1), there is an urgent need for a concerted conservation approach across its range, as called for by the CMS CAMI POW. To inform the development of a range-wide Conservation Strategy, Persian Leopard and conservation experts from all Range States and beyond have reviewed present knowledge and the conservation status of the Persian Leopard. These status reviews were published as a Special Issue of Cat News, together with topical papers addressing various aspects of the conservation of the species. The reviews have been conducted per metapopulation or region based on the distribution as discussed by Bleyhl et al. (2022), national boundaries or existing conservation initiatives. The present document is an excerpt of relevant information from this Special Issue. The Persian Leopard's range has been divided into four metapopulations/regions (Figure 1.1):

1. Caucasus Region (area of existing conservation strategy and WWF programme): Georgia, Azerbaijan, Armenia, parts of Russia, Iran, and Turkey (Khorozyan et al. 2022);
2. Alborz-Kopet Dagh Region: Iran, Turkmenistan, Kazakhstan, and western Uzbekistan (Farhadinia et al. 2022a);
3. Zagros Region: SW Turkey, Iraq, and Iran (Ghoddousi et al. 2022a);

4. Eastern Range: Pakistan [1], Afghanistan, Uzbekistan and Tajikistan (Ostrowski et al. 2022).
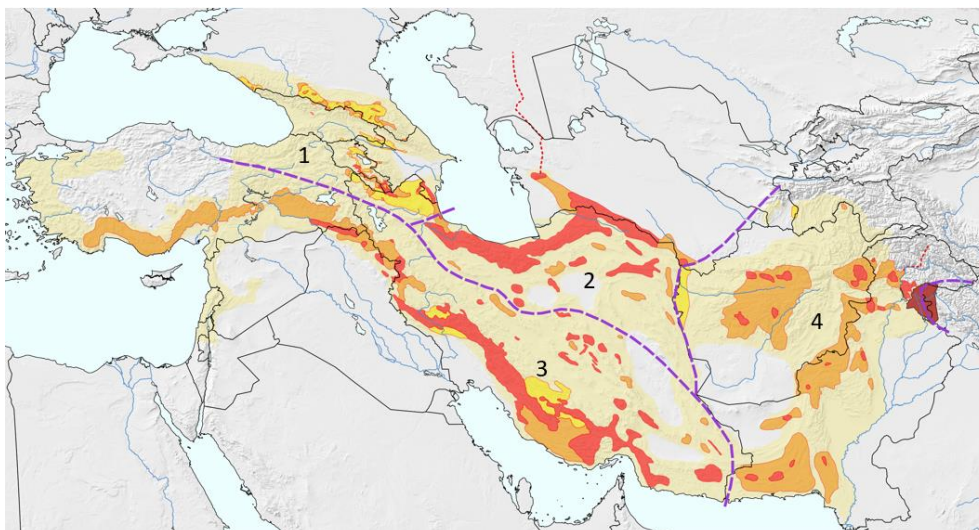
Figure 1.1. Distribution of the Persian Leopard *Panthera pardus tulliana* in past and present times according to IUCN Red List distribution categories: Red, extant; orange, possibly extant; yellow, possibly extinct; light yellow, extinct and delineation of regions for the Persian Leopard status review reports; 1 = Caucasus, 2 = Alborz-Kopet Dagh, 3 = Zagros, 4 = Eastern Range (Pakistan, Afghanistan, historic distribution in Uzbekistan and Tajikistan). The range delineation follows Kitchener et al. (2017) but there is evidence of intermixing present from east of the Indus River. Map courtesy to Peter Gerngross, based on Bleyhl et al. (2022), Farhadinia et al. (2022a), Ghoddousi et al. (2022a), Khorozyan et al. (2022), and Ostrowski et al. (2022).

Farhadinia et al. (2022a) for the Alborz-Kopet Dagh, Ghoddousi et al. (2022a) for the Zagros, Khorozyan et al. (2022) for the Caucasus, and Ostrowski et al. (2022) for the Eastern Range compiled all available contemporary records of leopard occurrences (Table 1.1) and estimated the minimum number of leopards per country (Table 1.2).

Table 1.1. Number of contemporary (>2000) records of leopard occurrences per meta-population and Range State according to the SCALP criteria: C1 = verified, C2 = confirmed, and C3 = unconfirmed observations.

Region	Range State	C1	C2	C3[1]	Total
Caucasus	Armenia	116	177	13	306
	Azerbaijan	46	10	0	56
	Georgia	2	3	9	14
	Iranian Caucasus	57	16	67	140
	Russian Caucasus	5	16	13	34
	Turkish Caucasus	3	0	1	4
Total Caucasus region		**229**	**222**	**103**	**554**
Alborz-Kopet Dagh	Iran[2]	278	263	-	541
	Turkmenistan	38	0	-	38
	Uzbekistan[3]	0	0	0	0
	Kazakhstan	10	0	-	10
Total Alborz-Kopet Dagh		**326**	**263**	**-**	**589**
Zagros	Iran[4]	215	105	55	275
	Iraq[5]	29	2	33	64
	Turkey[6]	0	0	0	0
Total Zagros range		**244**	**107**	**88**	**339**

[1] Uncertainties remain regarding the taxonomy of leopards in Pakistan, which is a contact zone between *P. p. tulliana* and *P. p. fusca* (Indian). The presence of both subspecies east of the Indus, has weakened the previous hypothesis of this river separating the two subspecies (Ostrowski et al. 2022).

Region	Range State	C1	C2	C3[1]	Total
Eastern range	Afghanistan	1	0	1	2
	Pakistan	127	3	0	130
	Tajikistan	0	0	0	0
	Uzbekistan[7]	0	0	0	0
Total Eastern range		**128**	**3**	**1**	**132**

NB: [1] C3 records were not considered for the Alborz-Kopet Dagh region, [2] N and NE, [3] W, [4] S and SW, [5] N, [6] SE, [7] E.

Table 1.2. An overview of the leopard status, CMS, CAMI and Bern Convention (BeCon) memberships of the Range States, and the minimum numbers of leopard individuals per country and region. The Persian Leopard is legally protected in all Range States. Status = IUCN Red List categories for the regional assessment. EN = Endangered, CR = Critically Endangered, EX = Extinct.

Region	Status	Range States	CMS	CAMI	BeCon	Minimum pop. size	Year national protection granted
Caucasus	CR	Armenia	Yes	No	Yes	3-9	1972
		Azerbaijan	No	No	Yes	6-17[1]	1976
		Georgia	Yes	No	Yes	1	1982
		Iran	Yes	Yes	No	No estimate	1965
		Turkey	No	No	Yes	No estimate	2003
		Russia	Yes	Yes	No	10	1956
Alborz-Kopet Dagh	EN	Iran	Yes	Yes	No	288-355[2]	1965
		Turkmenistan	Yes	Yes	No	60-80[3]	1970s
		Kazakhstan	Yes	Yes	No	0-5	2021
		Uzbekistan	Yes	Yes	No	No estimate	1983
Zagros	EN	Iran	Yes	Yes	No	200-320[4]	1965
		Iraq	Yes	No	No	10	2010
		Turkey	No	No	Yes	No estimate	2003
Eastern Range		Afghanistan	Yes	Yes	No	No estimate	2008
	CR	Pakistan	Yes	Yes	No	No estimate	1974
	(EX)	Uzbekistan	Yes	Yes	No	-	1983
	EX	Tajikistan	Yes	Yes	No	-	2008

NB: [1] number included juveniles, [2] based on ranger reports across PAs, [3] Team Bars Turkmenistan (2022), [4] based on Kiabi et al (2002), accuracy then and validity for today's situation is questionable.

1.1. Caucasus Region

In the Caucasus, the range of the Persian Leopard is confined to the mountain ridges of the Lesser Caucasus, Greater Caucasus, Talysh Mountains and their branches, and is heavily fragmented as a result of human activities. In this region, the Persian Leopard is considered to be Critically Endangered (Khorozyan et al. 2022). Continuous camera trap monitoring efforts have shown the minimum number of adult leopards to be 3−9 in Armenia, and 6−17 in Azerbaijan. Very few individuals have been recorded in the Turkish and Russian part of the Caucasus and only one confirmed individual is known from Georgia (Table 1.2). Within the Caucasus, Iran is considered to be the stronghold for leopard survival and holds the largest population in the region. In the Meghri Ridge of southern Armenia and Hirkan National Park of south-eastern Azerbaijan, leopard density was estimated as low as 0.34 adult leopards/100 km² (Khorozyan et al. 2008) and as high as 3 leopards/100 km² (Askerov et al. 2021) respectively. The latter high density, however, rather illustrates the habitat use by a small group of leopards (including young animals) in a protected area than an overall population density. Long-term and large-scale conservation efforts implemented by WWF and its partners have resulted in the recovery and breeding of a small population in the Zangezur triangle, including the south of Armenia, south-east of Azerbaijan's Nakhchyvan Autonomous Republic, and the adjacent part of north-west Iran. Some subadult leopards originating from this triangle have dispersed to other areas. Such events, however, are rare and documented only for males so far. Since the mid-2000s major threats to the Persian Leopard in the Caucasus region seem to be habitat fragmentation

intensified by the socio-economic development and politically challenging conditions (Khorozyan et al. 2022). The key issues for the Persian Leopards in the Caucasus region include a lack of breeding females and insufficient connectivity between the region's key areas[2] (Khorozyan et al. 2022, Farhadinia et al. 2022b, Rozhnov et al. 2022).

1.2. Alborz-Kopet Dagh Region

The Alborz-Kopet Dagh Region hosts 348-440 leopards, which makes it one of the largest continuous leopard hotspots across Asia (Jacobson et al. 2016). Almost 80% of the population exists in Iran, with the density in north-eastern Iran reported to vary between 2.63 individuals per 100 km² in Golestan National Park and 8.86 individuals per 100 km² in Sarigol National Park (Hamidi et al. 2014, Farhadinia et al. 2019). Some protected areas (e.g. Golestan National Park) in Iran have the highest densities of Persian Leopard ever confirmed (Hamidi et al. 2014). Turkmenistan holds the second largest Persian Leopard population, and Kazakhstan's leopard presence mainly depends on the transboundary transient individuals from Turkmenistan (Farhadinia et al. 2022a). A large percentage of suitable leopard habitat, however, is located outside of the existing network of protected areas; e.g., in the Iranian part of the Alborz-Kopet Dagh Region only 24% of suitable leopard habitat is gazetted as protected areas (Hosseini et al. 2019). Resident males were found to occupy a mean home range of 103.4 ± SE 51.8 km² (Farhadinia et al. 2018). Persian Leopards and their wild prey face multiple anthropogenic threats, also within protected areas, e.g. unsustainable livestock grazing and/or inadequate handling which depletes their habitat (Soofi et al. 2018, Khorozyan et al. 2020), illegal killing of leopards (mostly due to livestock predation; Farhadinia et al. 2022a, Soofi et al. 2022b), and wild prey depletion (Soofi et al. 2019). It is of high importance to promote coexistence between people and Persian Leopards. Conflict mitigation measures should be implemented in areas with high leopard mortality provoked by livestock losses due to leopard attacks, e.g. in north-eastern Iran (Soofi et al. 2022a). Selective management to target specific "problem" individuals should also be applied to effectively mitigate conflicts (Farhadinia et al. 2022a). Further suggested activities are education and training of pastoralists in regard to good livestock grazing practices, focusing on managing problem leopards, adequate monitoring of leopards and their prey, new protected area establishment as well as capacity building and awareness-raising in regard to conflict management and conservation initiatives in local communities and staff of protected areas are suggested activities (Farhadinia et al. 2022a).

1.3. Zagros Region

The Zagros Region covers the south-western part of the Persian Leopard's range including the Zagros Mountains and isolated mountain ranges in central, south-eastern and south-western Iran, south-eastern Turkey and northern Iraq. Over 75% of leopards of this metapopulation resides in Iran. In the Zagros Region, Persian Leopards have been studied only in a few protected areas. In these areas, the density was estimated to vary between 1.0–1.9 leopards/100 km² (Ghoddousi et al. 2010, Farhadinia et al. 2021). Further information comes from sporadic and opportunistic sightings. The status of Persian Leopards in south-eastern Turkey, northern Iraq and parts of western, south-eastern and central Iran is widely unknown. Based on records and expert knowledge (Ghoddousi et al. 2022a), the mapping of the potential distribution of the species revealed some 153,400 km² of habitat in Iran and Iraq (mainly along the Zagros Mountains). Additionally, the presence of the Persian Leopard is likely in another area of 70,500 km² which, however, needs further investigation. The main threats to leopards in this region include retaliatory killing by livestock pastoralists, prey depletion

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[2] Areas with breeding leopard populations, especially source populations, and important corridors connecting these areas.

and road accidents (Ghoddousi et al. 2022a; Soofi et al. 2019, 2022a). Moreover, identification and protection of (transboundary) corridors are considered to be conservation priorities given the increasing fragmentation of the leopard habitat.

1.4. Eastern Range

In the Eastern Range, Ostrowski et al. (2022) confirmed the presence of Persian Leopards in the central and eastern parts of Afghanistan, in the lower Himalayan range and south-western Pakistani borders. No confirmed contemporary records (>2000), however, were found in Tajikistan and Uzbekistan, where Persian Leopards are believed to be virtually extinct. No distinction was made between the *P. p. fusca* and *P. p. tulliana* subspecies in this regional assessment as it concerns an area with possible contact zones between the two subspecies. All recent leopard records were incorporated (Ostrowski et al. 2022). The leopard's population status in the Eastern Range remains unknown. Poaching was identified as a threat affecting leopards on a large scale across the Eastern Range. Main drivers for this illegal killing seem to be retaliation due to livestock destruction, exploitation for its fur and body parts and out of fear or pride (Ostrowski et al. 2022). In northern Pakistan and eastern Afghanistan, population decline is likely to have resulted from the rapid loss of the leopards' preferred habitat and its primary prey base. Infrastructural developments lead to further fragmentation of leopard habitat and isolation of segregated subpopulations, which then are exposed to depleted genetic variation and chronic stress (Asad et al. 2019). Across the region, research and awareness about the species are increasing. The leopard should be classified as conservation priority species in Pakistan and Afghanistan and its status should be monitored and initiatives to address human-wildlife conflicts be implemented (Ostrowski et al. 2022). Implementation of effective conservation measures remains limited and is complicated by regional political instability.

2. Cross-border protection priorities, migration routes and limitations

The management of transboundary Persian Leopard populations is subject to several political jurisdictions and faces different conservation challenges (Farhadinia et al. 2022b). The Persian Leopard has extensive spatial requirements and its populations are often transboundary spanning over geopolitical borders. Thus, in most of its range countries, the conservation of the Persian Leopard is dependent on transboundary collaboration (Farhadinia et al. 2022b). Its range encompasses 13 countries with 26% of its extant ranges in borderlands and in 10 countries the majority of the remaining Persian Leopard range lying in borderlands (Table 2.1; Farhadinia et al. 2022b).

Table 2.1. Percentage of country range in borderlands per Persian Leopard range country (Farhadina et al. 2022b).

Range States	% of country range in borderlands
Afghanistan	17.5
Armenia	100
Azerbaijan	100
Georgia	100
Iran	28.2
Iraq	100
Kazakhstan	100
Pakistan	74.8
Russia	100
Tajikistan	100
Turkey	100
Turkmenistan	91.1

Range States	% of country range in borderlands
Uzbekistan	100

The populations in the Armenia, Azerbaijan, Georgia and the Russian North Caucasus depend the most on borderlands. In these countries, the leopard conservation programme is active, which facilitates transboundary Persian Leopard conservation (see section 3; Zazanashvili et al. 2020). Beside this transboundary conservation initiative in the Lesser Caucasus one other initiative is taking place in the Hyrcanian forest (Askerov et al. 2019, Zazanashvili et al. 2020).

The Persian Leopard was added to the Central Asian Mammals Initiative (CAMI) of CMS and based on the study "Mapping transboundary hotspots for the Central Asian Mammals Initiative", six key transboundary areas for the Persian Leopard were recommended: entire Iran-Afghanistan border, Badhyz, Aral Paygambar, Kopetdag, south-western Ustyurt, and Babatag (Figure 2.1). Moreover, Farhadinia et al. (2022b) suggest to add four additional areas: Zagros (Iran, Iraq and Turkey), Lesser Caucasus (Iran, Armenia, Azerbaijan, Georgia, Turkey), Greater Caucasus (Georgia, Azerbaijan and Russia) and parts of the Hindu Kush range (Pakistan and Afghanistan; Figure 2.1).

Figure 2.1. The current range of the Persian Leopard and the locations of 10 key transboundary areas for Persian Leopards: 1) the entire Iran-Afghanistan border, 2) Badhyz, 3) Aral Paygambar, 4) Kopetdag, 5) south-western Ustyurt, 6) Babatag, 7) Zagros, 8) Lesser Caucasus, 9) Greater Caucasus and 10) Hindu Kush range (Farhadinia et al. 2022b).

The main challenges for the transboundary Persian Leopard populations are different levels of legal protection and management across national jurisdictions, military activities and armed conflict, and border security fences that block the movement of Persian Leopards and their prey (Farhadinia et al. 2022b). Neighbouring countries possibly have different agendas and available capacities and resources for the Persian Leopard conservation. These differences possibly impede the recovery of transboundary populations. Political unrest affects law enforcement and effective conservation. Occasionally leopards and other wildlife are killed by old mines too (Farhadinia et al. 2022b). Border fences and roads are issues for the transboundary movement of Persian Leopards. Border fences and walls may hinder movements of Persian Leopards and their prey along Iran–Turkmenistan, Afghanistan–Turkmenistan, Afghanistan-Pakistan, Turkmenistan-Kazakhstan, Iran-Armenia, Armenia-Turkey, Georgia-Turkey and Iran-Azerbaijan, and parts of Turkish borders (Farhadinia et al. 2022b).

Cooperation in conserving transboundary landscapes is an essential part to encourage intergovernmental partnerships. There is for example the concept of an international Peace Park to link biodiversity conservation with promoting peace. This has been proposed for the area between Arevik National Park in Armenia and Dizmar Protected Area in Iran, and Hawraman-Darbandikhan-QaraDagh areas in Iraq and Shaho Kohsalan and Buzin Marakhil Protected Areas in Iran (Farhadinia et al. 2022b). Moreover, conservation initiatives promoting joint conservation and research efforts between conflicting countries have the potential to motivate countries to work together in conservation (Farhadinia et al. 2022b). Transboundary cooperation is however not always feasible. If this is the case, each country can unilaterally enhance the conservation of their transboundary Persian Leopard populations (Farhadinia et al. 2021). Additionally, there is the need for joint and coordinated monitoring and information sharing programmes in regard to Persian Leopards and their prey (Zazanashvili et al. 2020, Ghoddousi et al. 2022b). A systematic monitoring framework will help identify knowledge gaps and priority areas to improve Persian Leopard conservation (Ghoddousi et al. 2022b). Moreover, exchange of information can improve the quality of Persian Leopard population estimates, lead to a better understanding on its status and help range countries to achieve their conservation targets and the objectives of regional conservation initiatives such as of the CAMI (Farhadinia et al. 2022b, Ghoddousi et al. 2022b). Additionally, effects of border fences on leopard movements and demography need to be better understood (Farhadinia et al. 2022b). The knowledge on the distribution of the Persian Leopard in borderlands should be improved by surveys such as in the borders between Turkey and Iran, Turkey and Iraq, Kopetdag Mountains along the Iran-Turkmenistan border, Babatag Mountains along the Tajikistan-Uzbekistan border, and Koytendag/Kugitang shared between Turkmenistan, Uzbekistan and Afghanistan, as well as the borderland between Afghanistan and Iran or Pakistan (CMS 2019, Farhadinia et al. 2022b). Beside the CMS, the Bern Convention on the Conservation of European Wildlife and Natural Habitats and the Convention on International Tarde in Endangered Species of Wild Fauna and Flora influence the conservation of large carnivores and their habitats in the range of the Persian Leopard (Farhadinia et al. 2022b). Furthermore, the Ecoregional Conservation Initiative for the Caucasus, implemented by the WWF Caucasus Programme, promotes a set of transboundary conservation targets and actions linked to the conservation of Persian Leopard and its prey (Zazanashvili et al. 2020). Additionally, the intergovernmental Economic Cooperation Organization (most of the range countries are members of it) can provide a framework for the establishment of transboundary cooperation for Persian Leopard conservation through the ECO's Division on Social Welfare and Environment (Farhadinia et al. 2022b).

The Persian Leopards currently only occur in a fraction of their historical range. Therefore, it is crucial to identify areas for restoring, connecting, and expanding extant populations (Bleyhl et al. 2022). Around 1,290,000 km² of potentially suitable habitat (especially in mountain regions) was identified based on habitat modelling (Belyhl et al. 2022). Additionally, five clusters of habitat patches were suggested that could potentially host Persian Leopard metapopulations: the Caucasus (Armenia, Azerbaijan, Georgia, Iran, Russia, Turkey), the Alborz-Kopetdag Mountains (Iran, Turkmenistan), the Taurus Mountains (Turkey), the Zagros Mountains (Iran, Iraq, Turkey), and the Hindu Kush-Western Himalayas (Afghanistan, Pakistan). Moreover 174 individual core habitat patches with more than 250 km² of highly suitable habitat were identified (Figure 2.2).
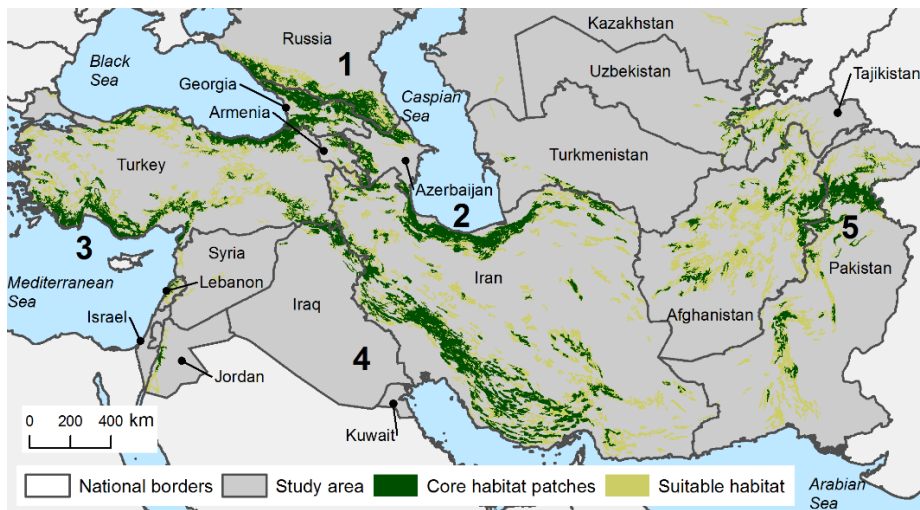
Figure 2.2. Study area (dark grey), predicted suitable habitat (light green) and core habitat patches (dark green) for Persian Leopards across their range. Numbers indicate the five candidate regions to host viable leopard metapopulations: (1) the Caucasus, (2) the Alborz-Kopetdag Mountains, (3) the Taurus Mountains, (4) the Zagros Mountains, and (5) the Hindu Kush-Western Himalayas. Due to most presence records coming from Iran, the models possibly underestimate habitat suitability in other countries (Belyhl et al. 2022). Moreover, prey availability, a key factor for Persian Leopard survival, could not be considered in the models due to the lack of consistent data across the range (Belyhl et al. 2022).

In the Caucasus, a small number of Persian Leopards occurs, mostly in the south (Askerov 2015, 2018). It is possible, that the population expands naturally towards north as there are records from Karabakh Upland, northern Armenia and Georgia (likely resulting from the conservation efforts of the last two decades (Askerov et al. 2015, Breitenmoser et al. 2017). Persian Leopards are also sporadically sighted in the Greater Caucasus (Yarovenko & Zazanashviil 2016). However, reaching a viable metapopulation in the Caucasus likely depends on substantial conservation actions such as mitigation of human-leopard conflict, reduction of Persian Leopard persecution, increasing prey availability and establishment of connectivity towards Iran and between core habitat patches (Moqanaki et al. 2013, Farhadinia et al. 2015, Babrgir et al. 2017, Maharramova et al. 2018, Rozhnov et al. 2020a, Bleyhl et al. 2021, 2022).

The cluster of core habitat patches in Alborz-Kopetdag Mountains in northern Iran and Turkmenistan is a stronghold for Persian Leopards and with its prey availability, landscape connectivity and protected area network likely the most important region for Persian Leopard survival (Hamidi et al. 2014, Farhadinia et al. 2019, Bleyhl et al. 2022). However, there are indications of increased poaching due to livestock depredation, which possibly severely reduced local populations (Kaczensky et al. 2019, Soofi et al. 2019, 2022a, Farhadinia et al. 2022a).

The Taurus Mountains in south-western Turkey also forms a cluster of suitable habitat patches. Information on the status of the Persian Leopard there is limited and no breeding leopards were recorded until now (Bleyhl et al. 2022). Possibly active translocation to this area could be needed to establish a viable metapopulation as the Taurus Mountains are quite isolated from the current larger source populations (Bleyhl et al. 2022).

Another cluster of suitable habitat patches is located along the Zagros Mountains. Several protected areas there host small stable Persian Leopard populations (Ghoddousi et al. 2010, 2022a, Bleyhl et al. 2022). Recent records from the border between Iran, Iraq and Turkey indicate that there is possibly a small leopard population there, but further conservation measures are needed to establish a larger viable metapopulation (Avgan et al. 2016).

The last cluster of habitat patches is found in the Hindu Kush and western Himalayas (Bleyhl et al. 2022). This region is quite isolated from the remaining Persian Leopard populations (Hosseini et al. 2019) but connected to the east with the Indian Leopard north of the Indus in Pakistan (Asad et al. 2019). In this area, Persian Leopards are threatened from loss of habitat and wild prey increasing the human-leopard conflict due to livestock depredation. Armed conflicts often limit the enforcement of conservation measures (Shehzad et al. 2015, Kabir et al. 2017, Bleyhl et al. 2022, Ostrowski et al. 2022).

Only 11% of the core habitat patch area is currently protected and much of the identified habitat is likely currently unoccupied (~70%) (Blehyl et al. 2022). The latter indicates high pressure on current Persian Leopard populations preventing them from substantial range-expansion (Bleyhl et al. 2022). Reasons for this is possibly persecution in retaliation or fear of Persian Leopards predating on livestock (Blehly et al. 2021, Soofi et al. 2022), insufficient prey base often resulting from poaching of prey (Ghoddousi et al. 2017). Key aspect is to foster coexistence with people and restoration of the prey species especially outside protected areas (Ghoddousi et al. 2020). Limited connectivity to current populations can prevent dispersal to currently unoccupied habitat. The limitations for re-occupation of suitable habitat differ across areas, therefore local studies are needed to identify appropriate conservation measures for each site(Bleyhl et al. 2022).

Potential corridors among core habitat patches were mapped and three priority regions for population recovery, with clusters of unoccupied patches that have a high connectivity to currently occupied patches were identified: the southern Caucasus, the southern Zagros Mountains, and the Hindu Kush-Spin Ghar (Bleyhl et al. 2022; Figs. 2.3 & 2.4).

Several of the identified corridors cross international borders indicating the importance of transboundary conservation for the Persian Leopard (Bleyhl et al. 2022).

The analyses of Bleyhl et al. (2022) suggest a major potential for larger, viable Persian Leopard metapopulations within their historical range, if conservation measures are implemented to stop and reverse ongoing population declines and local extinctions. There is a large potential for restoration of current Persian Leopard populations and for fostering recolonization of formerly occupied habitat (Belyhl et al. 2022).
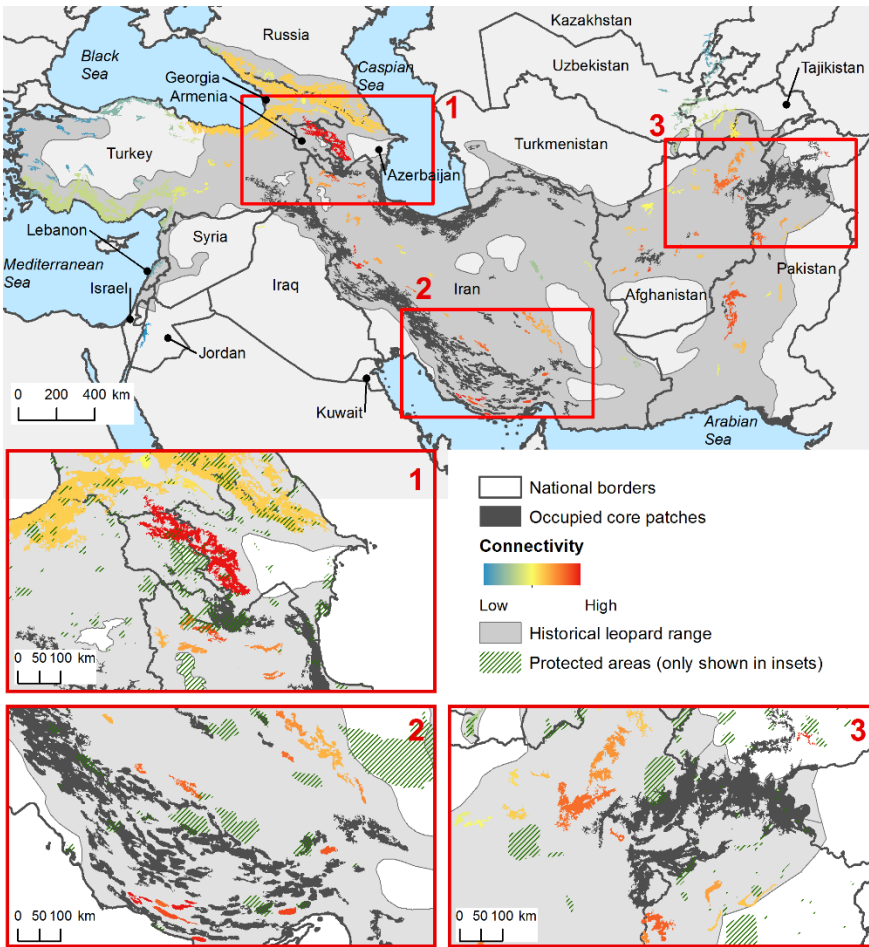
Figure 2.3. Connectivity of each unoccupied habitat patch (i.e., patches not overlapping with our extant distribution; coloured patches in the map) to its closest occupied patch (i.e., patches that overlap with our extant distribution; dark grey patches in the map). The three inset maps show the most promising regions for population recovery (clusters of unoccupied patches with high connectivity to current populations): (1) the southern Caucasus, (2) the southern Zagros Mountains, and (3) the Hindu Kush-Spin Ghar (Blehly et al. 2022).
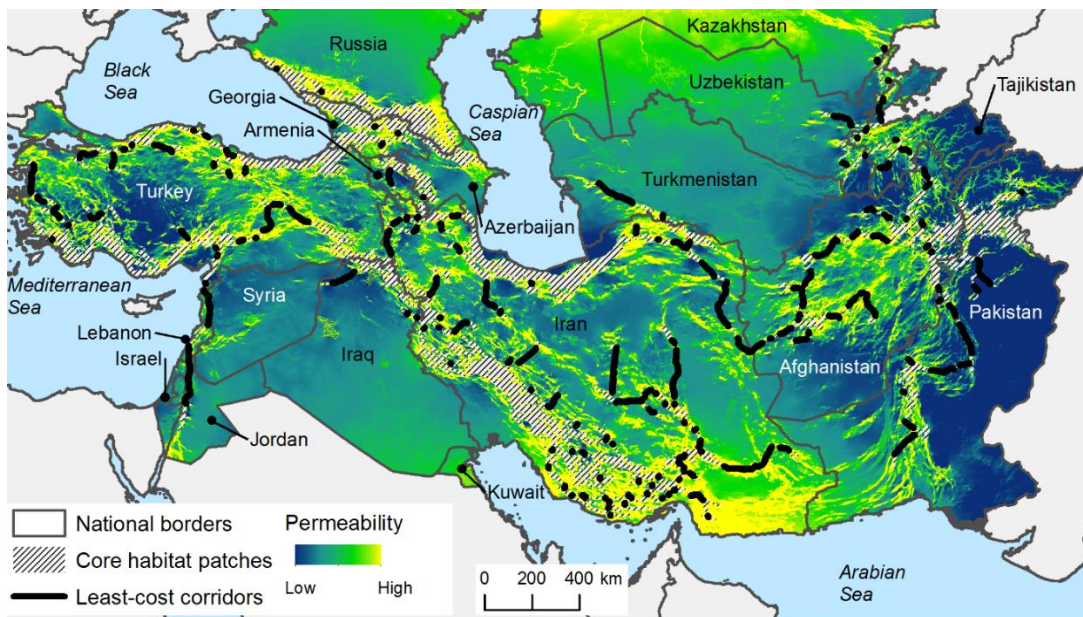
Figure 2.4. Location of the least-cost corridors from each core habitat patch to its closest neighbouring patch and to the closest neighbouring disjunct group of patches and the general permeability of the landscape towards leopard movement (Blehly et al. 2022).

3. Re-introduction efforts and current projects for the Persian Leopard

In the Caucasus, primarily in the Zangezur triangle, a long-term leopard conservation and monitoring programme was initiated by the national WWF teams of Armenia, Azerbaijan and Georgia in cooperation with national governments in 2002 (Khorozyan et al. 2022). This programme includes, providing assistance for establishing new or the management of already existing protected areas, establishment of wildlife corridors and engagement of local people in Persian Leopard Conservation and awareness raising, among other activities (Khorozyan et al. 2022). All possible efforts should be directed towards the creation and maintenance of transboundary and in-country connectivity of Persian Leopard habitats, and the continuation of support to protected areas, anti-poaching activities, and awareness-raising (Khorozyan et al. 2022).

Persian Leopard conservation has also been undertaken by the Iranian Department of Environment (Khorozyan et al. 2022). Additionally, several non-governmental organizations in Iran conduct in Persian Leopard research and conservation activities in several areas, such as population assessments and mitigation of human-leopard conflicts (Ghoddousi et al. 2022a). The non-governmental organization Nature Iraq cooperates currently with the Kurdish government agencies to establish a new protected area for the Persian Leopard (Ghoddousi et al. 2022a).

Persian Leopard reintroduction has started in the Russian Caucasus in 2007 (Khorozyan et al. 2022, Rhoznov et al. 2022). The goal of this project is to create a Persian Leopard population nucleus in the northern part of its historical range, which also provides the opportunity for breeding for Persian Leopards migrating north from the south (Rhoznov et al. 2022). The reintroduction allows also to re-integrate Persian Leopard genes from zoos into wild populations (Rhoznov et al. 2022). Until now, Persian Leopards were released in two regions: the North-West Caucasian and Central Caucasian (Ossetian) from the Sochi Breeding Center in the Russian Caucasus (Rhoznov et al. 2022). In July 2016 two males and one female were released in the Caucasian Natural Biosphere Reserve, in July 2018 one male was released in the Caucasian Natural Biosphere Reserve and another male and a female in the Alania National Park (Rhoznov et al. 2022). Successful survival of released animals during a full year cycle was confirmed, but breeding was not observed so far (Rhoznov et al. 2022). Until spring 2022, three males survived in Western Caucasus, and two females and one male in the Central Caucasus (Table 3.1). The main mortality reasons were natural hazards, e.g. deep snow and avalanches, and starvation due to weakness caused by the blood parasite *Cytauxzoon felis* (Rhoznov et al. 2022). In November 2021, an unknown wild male leopard was pictured in the territory of Kabardino-Balkaria, where one of the released females established her home range (Rhoznov et al. 2022). Two more wild Persian Leopards were recorded in 2022 in February and March at the territories of Chechnya and Dagestan, respectively. The present holding capacities of the breeding centre is not enough to provide the essential number of Persian Leopards needed to increase the efficiency of the programme (Rhoznov et al. 2022).

Table 3.1. Summary information on leopards bred in the Sochi Breeding Centre and released to the Russian Caucasus. Over-all mortality of released animals was 40% (20% during 1st year after release).

Number of leopards	Total	Males	Females	Western Caucasus	Central Caucasus
Born in the Center	25	12	13	-	-
Trained for releasing*	20	10	10	-	-
Assessed for readiness for living free	13	7	6	5 males 2 females	2 males 4 females

Number of leopards	Total	Males	Females	Western Caucasus	Central Caucasus
Released to the wild	10	6	4	4 males 2 females	2 males 2 females
Survived in the wild for 1 year	8	5	3	4 males 1 female	1 male 2 females
Died in 1st year after release	2	1	1	1 female	1 male
Died in 2nd year after release	2	1	1	1 male 1 female	0
Still alive in the wild in February 2022	6	4	2	3 males	1 male 2 females
Having bred in the wild	0	0	0	0	0

* 5 leopards in training in the SBC in February 2022

The Persian Leopard Breeding Programme in cooperation with the Felid Taxon Advisory Group of the European Association of Zoos and Aquaria (EAZA) is responsible for securing a self-sustaining captive population with the highest possible genetic diversity (Ferreira & Sliwa 2022). The primary goal of the Persian Leopard EAZA Ex-situ Programme (EEP) is to ensure that the captive population is self-sustaining and genetically and behaviorally healthy so that it could serve as source population for reintroductions or reinforcements in the case that the wild population declines further (Ferreira & Sliwa 2022). Currently, the ex-situ population is serving as a source for breeding Persian Leopards in the Sochi Breeding Center in the Russian Caucasus, but also aims to introduce further new founders into the captive population (Ferreira & Sliwa 2022).

4. Existing Conservation Strategies and National Action Plans

The Strategy for the Conservation of the Persian Leopard was developed in the Caucasus Ecoregion in 2007 (Breitenmoser-Würsten et al. 2007) and 2017, and informed the development of the National Action Plans for Armenia, Azerbaijan and Georgia in 2009 (Caucasus Leopard Working Group 2017) and 2019 (WWF Armenia 2019). Implementation of the long-term leopard conservation and monitoring programmes by WWF teams and national governments along with the restoration of the leopard's wild prey base (either through hunting bans, specific conservation measures or reintroduction programmes) in these countries has facilitated the leopard recovery in the South Caucasus, specifically in the Zangezur triangle (Khorozyan et al. 2022). In 2017, the 2007 Caucasus Conservation Strategy was revised and updated, with a specific focus on formulating more tangible Results and more realistic Activities to enable successful implementation of the revised Strategy (Caucasus Leopard Working Group 2017). The revised 2017 Strategy was concretised in NAPs that need to be implemented in order to reach the next phase for the conservation and recovery of the Persian Leopard in the Caucasus (Caucasus Leopard Working Group 2017). In Iran, a Roadmap for the conservation of cats including the leopard was developed in 2012 in order to inform the conservation of indigenous cat species (DoE 2012, Sanei et al. 2016). In Kazakhstan, the Persian Leopard Action Plan 2021-2025 was adopted in 2022 (CADI 2022, unpublished).

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