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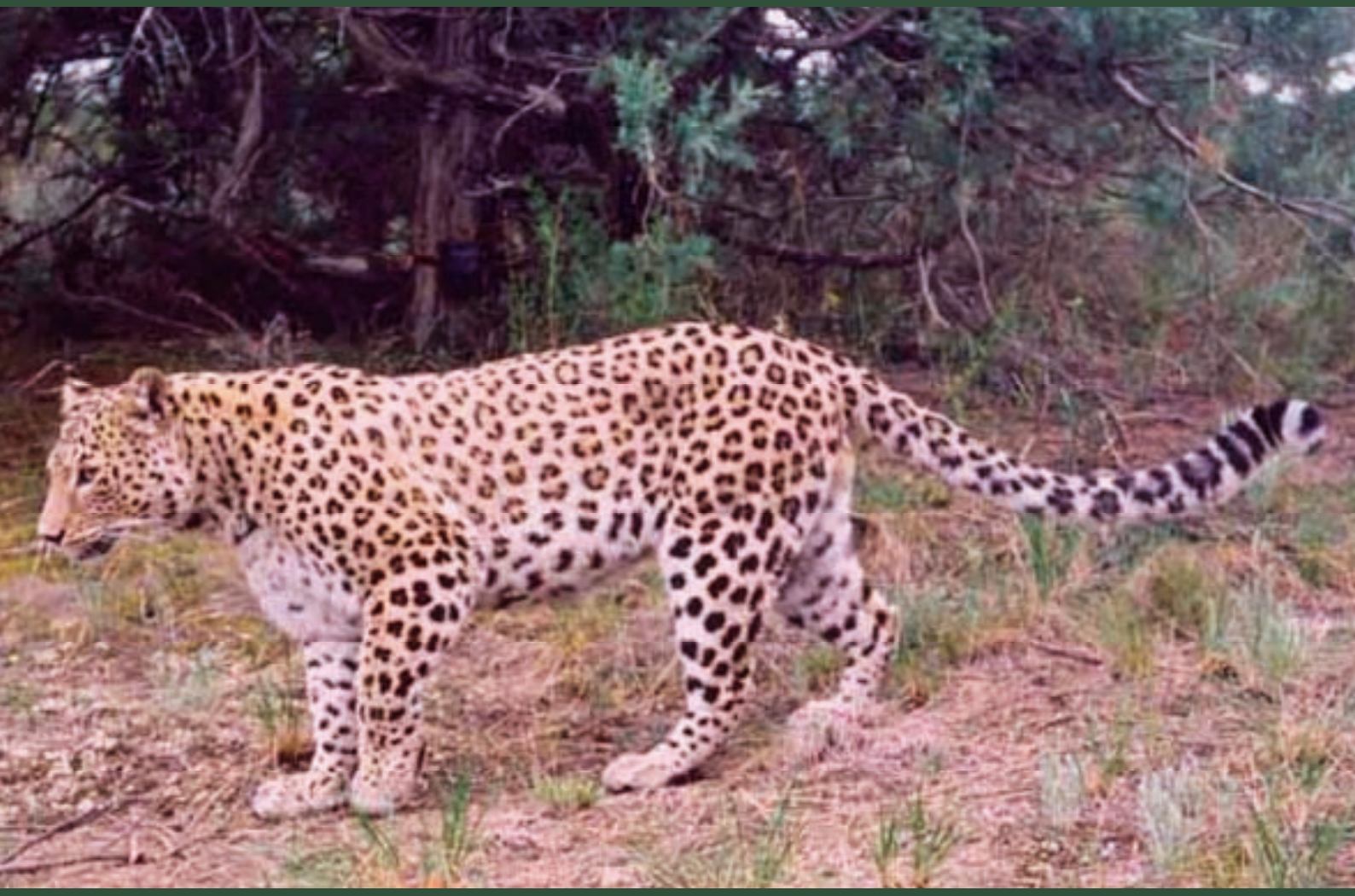

Status and Conservation of the Leopard in the Caucasus

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Conservation of the Leopard in the Caucasus

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This report attempts to compile and analyze all existing data on leopards and their conservation in the Caucasus creating a sound basis for the development of a leopard conservation strategy for the entire region. The Caucasus spans 6 countries and has been recognized as globally outstanding for its biodiversity. The leopard was identified as top priority species by the Ecoregional Conservation Plan (ECP), a key strategic document for biodiversity conservation in the region. Information on leopards before year 2000 has mainly been based on indirect evidences (tracks, skins). No scientific research or direct conservation action has been carried out during that time. Despite the fact that leopards indirectly benefited from the establishment of protected areas, they have been directly persecuted. As a result, their numbers have been dramatically reduced. Beginning in 2001, WWF has started to systematically investigate the status of leopards in the Caucasus through surveys and field monitoring. Additionally, urgent conservation measures have been implemented. This work not only improved the situation for the leopard but also managed to shift public opinion and perception. The leopard has become a symbol for the need of cooperation among the Caucasus countries because this wide-ranging cat can not be saved by one country alone.

Purpose of the report

The main purpose of this report is compiling and analyzing all existing baseline data on leopard conservation in the Caucasus to generate a sound basis for the development of a leopard conservation strategy for the entire region: a long-term vision, main strategic directions for its realization, as well as important milestones on this way, identified and agreed by national representatives of main stakeholder groups. This will create clear guidelines for further preparation and implementation of National Action Plans for leopard conservation in the ecoregion's countries.

The Caucasus

The Caucasus region, historical-geographically interpreted as the isthmus between the Black and Caspian seas, covers a total area of some 580,000 km^2, and spans six countries – Armenia, Azerbaijan, Georgia, the North Caucasus part of the Russian Federation, northeastern Turkey, and part of northwestern Iran (Fig. 1).

The Caucasus Isthmus is a region of natural contrasts and is composed of several prominent elements, including the Greater Caucasus Range, (Fig 2; highest peak: Mt. Elbrus, 5642 m a.s.l.), the Lesser Caucasus Mountain Chain (up to 4000 m a.s.l.), the Talysh-Western Alborz Mountains (up to 3200 m a.s.l.) at the south-western part of the Caspian Sea coast, and the South Caucasian Highlands covering parts of Asia Minor, Armenian and Iranian uplands

Fig. 1. Map of the Caucasus ecoregion (within red boundaries), with the Greater Caucasus in the north and the Lesser Caucasus in the south.

(highest point: Mt. Ararat (Agri Dagi), 5165 m a.s.l.).

Forests (Fig. 3) are among the most important biomes for biodiversity conservation in the Caucasus, covering around 112,000 km^2, nearly one-fifth of the region. High mountain habitats occupy more than 100,000 km^2 or around 17 % of the region. Mountain broadleaved forest, open dry woodlands and high mountains (primarily sub-alpine zone) are the main habitats of leopard in the Caucasus.

An estimated 150 mammal species occur in the Caucasus. Of these, 19 are endemic to the region (Zazanashvili *et al*. 1999). There are a number of important flagship species in the region, of which the leopard is probably the publicly best known and the most celebrated in poems, rhymes, and songs. The leopard was widespread throughout the Caucasus at the beginning of the 20th century but is now reduced to only certain inaccessible areas of the region. The leopard has always evoked mixed emotions of fear, hatred and respect among local people.

The Caucasus is one of WWF's Global 200 Ecoregions (#78 Caucasus-Anatolian-Hyrcanian Temperate Forests), identified as globally outstanding for biodiversity (www.worldwildlife.org/science/ecoregions/). One of the most biologically rich ecoregions on earth, the Caucasus is ranked among the planet's 25 most diverse and endangered hotspots as well (Mittermeier *et al*. 1999; Myers *et al*. 2000). The Caucasus is also a globally significant centre of cultural diversity, where a multitude of ethnic groups and languages intermingle over a relatively small area. The 2006 IUCN Red List for Endangered Species™ (www.redlist.org) identifies 57 species and 5 subspecies of globally threatened vertebrates in the Caucasus, among them 20 species and 3 subspecies of mammals, including leopard as *Panthera pardus saxicolor* (Endangered).

The conservation of the rich Caucasian biodiversity is a great challenge and focus of WWF's work in the region: WWF and over 160 representatives from governments, universities and NGOs of all six Caucasus countries established the Ecoregional Conservation Plan (ECP; Williams *et al*. 2006). The ECP

Fig. 2. Greater Caucasus range in Georgia (Photo WWF Caucasus Programme Office).

is a comprehensive strategy for action to protect biodiversity and to support regional development in the Caucasus. Its purpose is to serve governments as well as national and international organizations as an action guideline. At the same time, the ECP is a strategic planning instrument to help governments with the implementation of their obligations towards international conventions, especially the Convention on Biological Diversity (CBD). The Convention on Biological Diversity (CBD) has been ratified by all six countries of the Caucasus region (Armenia 1993, Georgia 1994, Russia 1995, Iran 1996, Turkey 1997 and Azerbaijan 2000). With signing the CBD the countries committed themselves to reduce the present rate of species loss significantly on national, regional, and global levels until 2010. The leopard has been identified as one of the top priority species by the ECP. Additionally, leopard conservation is a priority topic for the Caucasus Biodiversity Council consisting of representatives from governments, NGOs and science of ecoregion's countries. The Caucasus Biodiversity Council oversees the implementation of the ECP.

Leopard conservation in the Caucasus up to 2000

The first scientific publication on mammals/carnivores in the Caucasus, which includes some information on leopard occurrence throughout the region appeared at the beginning of the 20th century (Dinnik 1914, Satunin 1914, 1915; etc.). Afterwards, a considerable number of scientific publications followed, basically covering the geography of the species based on facts about revealing tracks or skins of killed animals in different parts of the Caucasus. On the other side in the course of the 20th century, actually no research has been carried out devoted to the direct study of the species taxonomy, populations' status, ecology, or conservation issues.

In parallel there were no direct field conservation actions aiming at protecting the leopard during the 20th century. However, the leopard indirectly benefited from the development of protected

Fig. 3. Rich broadleaf forest in the Talysh Mountains, Azerbaijan (Photo WWF Azerbaijan).

Table 1. Leopard nomenclature according to Red Data Books of former Soviet countries and USSR

Country (edition)	Year of Red Book	Common name	Scientific name
Armenia	1987	*Front Asian leopard*	*Panthera pardus tullianus Valenciennes, 1856*
Azerbaijan	1989	*Front Asian leopard*	*Felis pardus tullianus Valenciennes*
Georgia	1982	*Leopard*	*Felis pardus L.*
Russian Federation (1st edition)	1983	*Front Asian leopard*	*Panthera pardus tulliana*
Russian Federation (2nd edition)	2001	*Leopard*	*Panthera pardus (Linnaeus, 1758)*
USSR (1st edition)	1978	*Front Asian leopard*	*Panthera pardus tullianus*
USSR (2nd edition)	1984	*Front Asian leopard*	*Panthera pardus ciscaucasica (syn. P.p. tulliana)*

areas which were mainly created for the conservation of biologically valuable forest ecosystems and the establishment of hunting reserves. These actions certainly contributed to the preservation of leopard populations up to our time, despite the dramatic reduction of their numbers. Especially the following protected areas played a significant role for the survival of the leopard. In the eastern part of the Greater Caucasus: Lagodekhi (established in 1912, Georgia), Zakatala (1929, Azerbaijan), Batsara and Tusheti (1935, 1980, Georgia) strict nature reserves; between Greater and Lesser Caucasus on Iori-Mingechaur highlands: Vashlovani (1935, Georgia) and Turianchai (1958, Azerbaijan) strict nature reserves; in the Lesser Caucasus: Gioi-Giol (1925, Azerbaijan), Khosrov and Shikahogh (1958, Armenia) strict nature reserves; in the South Caucasian Highlands: protected areas Marakan, Arasbaran and Kiamaki (1966, 1971, 1974, Iran), and some others. The apparent neglect of the leopard by the scientific and conservation community in the 20th century is comprehensible only in light of the historic socio-cultural circumstances: most of the leopard's range in the Caucasus was part of the Soviet Union in which predators such as the leopard were seen as pests and detrimental to agricultural and livestock production. Therefore, the systematic extermination of leopards and other predators was encouraged by state authorities through a bounty system. Only retrospectively scientists and conservationists realized the dramatic decline of the Caucasian leopard population. This decline appeared so severe that from the 1960ies until the end of the 20th century when WWF started its investigations, the majority of scientists really doubted the existence of the species in most parts of the Caucasus.

Fig. 4. Anti-poaching unit in Armenia (Photo K. Manvelyan).

Nevertheless, the only action that has been taken was including the species to the Red Lists/Books of the Caucasus countries. In particular, the first Red List of Georgia including data on the leopard was approved by the Council of Ministers in 1977. Afterwards, the Red Data Book of Georgia was published (1982). The leopard is included in the two editions of the Red Data Book of the Russian Federation (1983, 2001), Red Data Books of Armenia (1987) and Azerbaijan (1989). In all publications it was registered as a species under the threat of extinction. This status doesn't directly correspond to IUCN Red List Categories; it could be considered as Critically Endangered or Endangered. "Soviet" categorization was not based on strong criteria; it was an expert driven process. With the same status, the leopard was included in two editions of the Red Data Book of the USSR (1978, 1984). All these documents had uncertain legal basis. Interesting to note that at the same time different nomenclature was used (Table 1; Lukarevsky *et al*. 2007a).

It is symptomatic that after publishing of the Red Data Books mentioned above, not a single case of leopard killing has been officially registered right up to 2002, when the first WWF project started. This indicates that these editions had no real legal basis and accordingly were not supported with adequate law enforcement measures.

The legal basis for leopard conservation has begun to improve since 2000, when in Azerbaijan "Regulation on Red Data Book" was adopted by the resolution of the Cabinet of Ministers of Azerbaijan; the last revision of the Red List of Georgia was made recently, using IUCN methodology, and was approved by the President of Georgia in 2006 in accordance to the Law of Georgia on Red List and Red Data Book (of 2003, prepared with the support of the WWF). In this Georgian Red List, the leopard is listed as Critically Endangered. In Armenia the List according to the Red Data Book (with no changes) was officially approved by the Government in 2006.

In general, it should be noted that during the 20th century there was no adequate attention paid neither to research nor to the conservation of leopards throughout the Caucasus, which subsequently created the critical situation with regard to the species' population in the region.

Leopard conservation in the Caucasus since 2000

The situation, both with research and conservation of the leopard, has significantly changed during the last 5-6 years, when the first phase (2001-2005) of WWF's project on leopard conservation in the Caucasus has been implemented thanks to support of WWF-Switzerland and personally Heinz Stalder. Since 2003, WWF-Germany has also actively supported the project.

The main goal of the first phase of the project was the identification of conditions of leopard populations in the Caucasus and the implementation of urgent, primary conservation measures in some regions of its distribution (South Armenia and South Azerbaijan). In particular:

- Surveys have been carried out in the Greater and Lesser Caucasus and in the South Caucasus Highlands[1] (Armenia, Azerbaijan, Georgia, Iran, Russia, Turkey; Lukarevsky *et al*. 2007b); during the project implementation period, colleagues from the NGO NACRES have discovered a so far unknown leopard occurrence in the Vashlovani Reserve (Eastern Georgia, Iori-Mingechaur plateau, between Greater and Lesser Caucasus). This project has been supported by GEF/WB Georgia Protected Areas Development Project.
- The WWF project has supported the planning process of new protected areas, important for preserving the species in the Caucasus (Ordubad and Hirkan National Parks, Akharbakhar section of Illisu reserve, Azerbaijan, protected areas Zangezur and Arevik, Armenia); by Presidential Decree of the Republic of Azerbaijan and efforts of the Ministry of Ecology and Natural Resources of Azerbaijan, Ordubad National Park was founded in 2003 (12,000 ha; development and enlargement of which is included in GEF/WB on-going Azerbaijan Rural Environment Project), Hirkan National Park in 2004 (21,500 ha) and the Akhabakhar section of Illisu reserve in 2004 (5,000 ha). Planning of new protected areas in South Armenia is coming to an end; management plans are under development, basic infrastructure will be created; the project is supported by the Critical Ecosystem Partnership Fund (CEPF) and support from the Norwegian government is expected as well.
- Assistance has been rendered to existing protected areas for strengthening protection programs in Armenia and Azerbaijan (Khosrov and Shikahogh reserves, Armenia, Ordubad and Hirkan National Parks, Azerbaijan);
- An anti-poaching brigade has been established and run in southern Armenia (Fig. 4);
- Systematic field monitoring has been set up and run in Armenia and partially in Talysh Mountains of Azerbaijan (Fig. 5);
- School education campaigns have been organized in leopard distribution areas in Armenia and Azerbaijan (Fig. 6);
- Informational meetings and seminars have been conducted with the border guards in Armenia and Azerbaijan;
- Increase of penalties for killing leopards has been lobbied, e.g. in Armenia penalty for damaging leopard has been repeatedly increased and currently amounts USD 7,085. In Azerbaijan, before 2004 the penalty was USD 337, and today it is USD 3,300. If the killing happens in a protected area, it is three times higher.
- A number of communication and awareness raising materials have been produced and distributed.

During the initial phase of project implementation important positive results on the ground were achieved. Traces of territorial leopards have been recorded on a regular basis in southern Armenia, particularly in the Meghri mountain range, including Shikahogh Nature Reserve, and in March 2005 a photo of a free living leopard was taken with a camera-trap installed by the group led by Igor Khorozyan. According to the monitoring results (Lukarevsky *et al*. 2007b), the number of bezoar goats increased up to 25%, and the presence of leopards in Meghri mountain ridge became permanent. The project has certain achievements in Azerbaijan too, particularly in Talysh Mountains and Nakhchyvan. In January 2007, a photo of a free living leopard was taken in Talysh Mountains with a camera trap installed by expert Elshad Askerov and local supporter Babakhan Rakhmanov.

Fig. 5. Tracks left by leopards are very important for surveys (Photo WWF, F. Mörschel).

Additionally, the first phase of WWF's project - together with efforts of colleagues from NACRES, Georgia, experts Igor Khorozyan and Alexander Malkhasyan, Armenia, colleagues from Institute of Zoology of National Academy of Sciences of Azerbaijan, expert Emre Can, Turkey, expert Ali Aghili, Iran and other colleagues who contributed to leopard conservation in the Caucasus managed to shift the opinion and perception of politicians, the media and local people in the region: They not only began to realize that the leopard still exists in a number of areas in the Caucasus; instead of the previously hated and dangerous animal they now recognize the leopard as a flagship species on the verge of extinction which urgently needs special attention for its survival. The leopard now more and more becomes a symbol for the need

[1] The leading role in determining status of leopard populations in regional scale and also, in training of local specialists and establishing field monitoring played Dr. Victor Lukarevski.

Fig. 6. Education program in Armenia (Photo K. Manvelyan).

of cooperation among the Caucasus countries because it is so obvious that this wide-ranging cat can not be saved by one country alone. This could be seen at the Caucasus Ministerial Conference held in March 2006 in Berlin where the leopard was the symbol of the conference. This conference brought together representatives of all 6 Caucasus countries, including the environmental ministers of Armenia, Azerbaijan and Georgia.

The first phase of WWF's project addressed urgent conservation needs of leopards. As a next step, a broadly accepted ecoregional vision and strategy are needed to effectively enhance leopard conservation. This ecoregional vision and strategy has to be translated into corresponding national action plans officially approved by relevant governmental organizations.

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First of all, we would like to thank Ministry of Nature Protection of Armenia, Ministry of Ecology and Natural Resources of Azerbaijan, Ministry of Environment Protection and Natural Resources of Georgia, Department of the Environment of Iran, Ministry of Natural Resources of Russian Federation, and Ministry of Environment and Forestry of Turkey for their crucial input in initiating ecoregional conservation work and particularly leopard conservation activities in the Caucasus. We would like to acknowledge the following governments, governmental institutions and aid agencies, multilateral donors, foundations and international nature conservation organizations as well, who supports ecoregional conservation work and/or, directly or indirectly - leopard conservation activities in the Caucasus: German Federal Ministry for Cooperation and Development (BMZ) and KfW Development Bank, the Government of Norway, the John D. and Catherine T. MacArthur Foundation, the Global Environmental Facility, the World Bank, WWF International, WWF Switzerland, WWF Germany, and WWF Norway, Conservation International and the Critical Ecosystem Partnership Fund. We are also grateful for support receiving from Caucasus Biodiversity Council; we thank all our colleagues, experts and specialists from the ecoregion's countries, who gave input in different stages of developing ecoregional activities and implementation of the initial phase of leopard conservation work in the Caucasus, as well as for fruitful collaboration (see Williams *et al.* 2006).

And finally, special thanks to IUCN, IUCN/SSC Cat Specialist Group, and particularly its Co-Chairs Dr. Urs Breitenmoser and Dr. Christine Breitenmoser, and Dr. David Mallon, Co-Chair of the IUCN/SSC Antelope Specialist Group, for leading and coordinating the production of the report and development of regional strategy for leopard conservation in the Caucasus Ecoregion.

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Biology and Ecology of the Leopard in the Caucasus

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The Caucasus leopard is large, weighing up to 60 kg, and light in colour. The taxonomy has been confused, with at least three named forms reportedly occurring in the area. It is now considered that all leopards occurring in the Caucasus, northern Iran and Turkmenistan, are a single form, referred to here as *Panthera pardus saxicolor*. Very little field research has been conducted on the biology and ecology of leopards in the Caucasus. Estimates of abundance range from 0.4 individuals/100km^2 based on scat analyses to 1 per 100 km^2. Anecdotal reports indicate that one male overlaps the ranges of 2–3 females. Leopards in the Caucasus often move along mountain ridges that offer a wide view of the surrounding area and frequently make use of established paths. A dietary study based on scat analysis showed that wild boar formed the main prey in south Armenia. Wild ungulates are generally considered to constitute the main prey, along with smaller mammals such as hares and porcupines and game birds. Habitat consists of subalpine meadows, broad-leaved forests and rugged ravines from 600–3,800m in the Greater Caucasus and rocky slopes, mountain steppes, and sparse juniper forests in the Lesser Caucasus and Iran.

Description of the "Caucasus leopard"

Leopards living in the Caucasus are rather large animals, somewhat larger than in the Russian Far East. The weight may reach 60 kg and the body length varies from 126 – 171 cm; higher values found in the literature are very likely erroneous. They leave footprints of about 9 – 11 by 8 – 9 cm (Fig. 1). Condylobasal length[1] is 185 – 223 mm for males and 186 – 188 mm for females, zygomatic width 133 – 172 for males and 122 – 135 for females (Heptner & Sludskii 1972).

The colour of leopards in the Caucasus is usually light and pale (Fig. 2). The main background colour is grey-ochre, sometimes light grey with sandy or various intensities of reddish, but always relatively faint. The colour is more vivid on the back. The spots are relatively few, usually not pure black, and often with a brownish tinge. Most of the spots are compact and relatively small. Rosettes consist of three to five spots. There are also dark-coloured individuals. Their spots are larger and sparser. A significant number of spots form complete rings.

[1] Condylobasal length and zygomatic width are standard measures to describe skull size, which directly correlated with body size.

Short review of the taxonomic classification of the leopard in the Caucasus

Various authors have identified the leopards in south-central Asia and the Near East as belonging to the subspecies *P. p. tulliana* Valenciennes, 1856 (a.o. Flerov & Gromov 1934, Flerov 1935, Baryshnikov 1987). Other Russian researchers called this leopard *P. p. ciscaucasica* Satunin, 1914 (Heptner & Sludskij 1972, Sludskij 1976, Sokolov 1986), while western scientist tended to use the name *P. p. saxicolor* Pocock, 1927 (Misonne 1959, Tylinek *et al*. 1987, Shoemaker 1977, 1978).

P. p. tulliana has commonly been used in the Soviet literature. According to Heptner & Sludskij (1972) *tulliana* has formerly been widely distributed in Asia Minor. Its occurrence was confined to the extreme south-western corner of the Turkish Peninsula between the lower course of the Chediz and Antalya Bay already during the 1940s and 1950s. It is possible that these leopards originated from a glacial refuge after the last ice age and never have been in contact with the leopards in the Caucasus eco-region. Thus the subspecies status in southern Turkey and Syria/ northern Israel remains unclear and still needs to be clarified. Although zoologists have described five subspecies for the area of the former Soviet Union, Heptner and Sludskij (1972) recognise only two: *P. p. orientalis* in the Russian Far East and *P. p.ciscaucasicus* or *saxicolor* in the Trans-Caucasus, the Great Caucasus, Iran (at least northern Iran) and Turkmenistan. Based on morphology, Khorozyan *et al*. (2006) suggested to retain the name *P. p. ciscaucasica* (= *saxicolor*, *transcaucasica*) for the Caucasus, northern Iran and Turkmenistan.

Fig. 1. Leopard tracks (Photo D. Mallon).

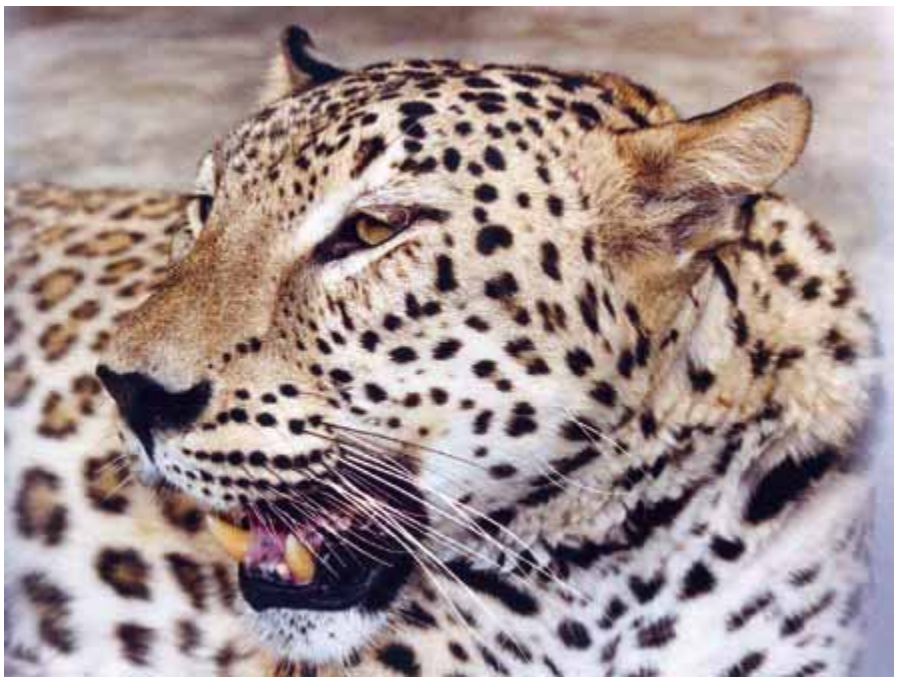

Fig. 2. Leopards from the Caucasus are typically light and pale (Photo WWF Caucasus Programme Office).

Newer revisions of the taxonomy of the leopard based on genetics identified the leopards living in the Caucasus eco-region as belonging to *P. p. saxicolor* (Miththapala *et al*. 1996, Uphyrkina *et al*. 2001; Fig. 3). Miththapala *et al*. 1996 have united seven putative subspecies from Central Asia and the Arabian Penninsula into *P. p. saxicolor*. Uphyrkina *et al*. 2001 confirmed this with the exception of the Arabian Penninsula. They think that these leopards belong to an own subspecies, *P. p. nimr*. We suggest following this proposal and consider the leopard in the Caucasus and adjacent areas to belong all to the same subspecies, *P. p. saxicolor*[2].

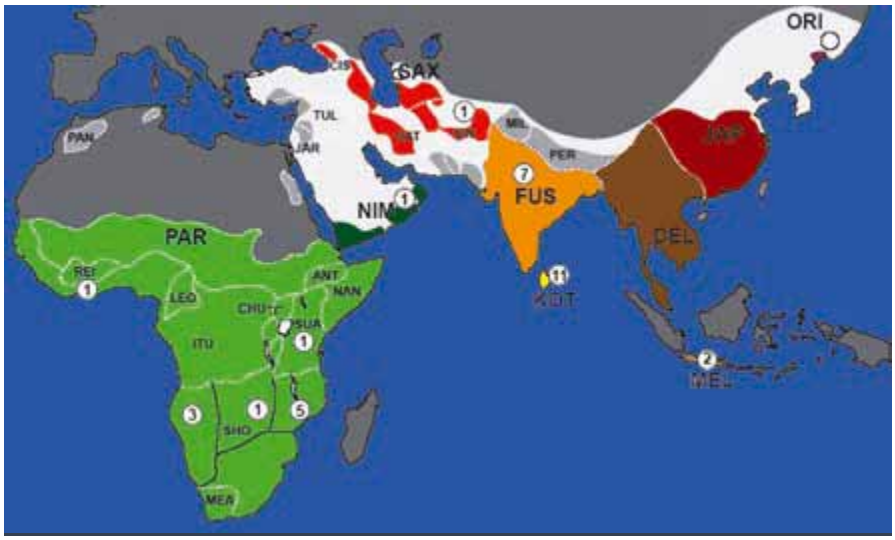

Fig. 3. Historic (dark grey) and present (various colours) geographical distribution of leopards; distribution of named classical leopard subspecies (big and small three-letter codes together) and distribution of revised subspecies classifications according to Uphyrkina *et al*. 2001 (big three-letter codes in coloured polygons); sample collection sites and number of samples from each site are given in circles. Classical subspecies that were not examined are given in light grey. PAR = *Panthera pardus pardus* African leopard; NIM = *P. p. nimr* Arabian leopard; SAX = *P. p. saxicolor* Persian leopard, FUS = *P. p. fusca* Indian leopard, KOT = *P. p. kotiya* Sri Lankan leopard, MEL = *P. p. melas* Javan leopard, DEL = *P. p. delacouri* North China leopard, JAP = *P. p. japonensis* North China leopard, ORI = *P. p. orientalis* Far Eastern leopard. Map redrawn from Uphyrkina *et al*. 2001.

Life history data

No data on the duration of mating and birth time are available from the Caucasus eco-region. Observations of leopards in captivity have shown that oestrus in female leopards lasts for 12–18 days, with an oestrus cycle of 6–210 days, with an average of 52.6 days (Shereshevsky 1940a,b, Eaton 1977). This variability of cycle allows leopard females to mate relatively soon again after the loss of a litter, which has great significance for the survival of the species. It indicates that the reproduction is not strictly seasonal. However, the Caucasus is, within the species' huge distribution range, one of the regions with distinct seasons. We saw pairs of adult leopards in January, February, May and July in southern Nakhchyvan at the border with Armenia, and in Armenia itself (Lukarevsky *et al*. 2004). The peak of fertility seems to be in spring and the first half of summer (from March until July). Vereshagin (1942) describes that leopards in the Caucasus become sexually aroused in January indicating a seasonal reproduction. Small cubs are most often seen in April and May, but it is possible to find them during other months (Heptner & Sludskij 1972). Seasonality in reproduction seems to be more prominent in the Greater Caucasus – where young leopards need their mothers to survive through the winter. In captivity, litters comprise one to four kittens, but no litters with more than two kittens have been reported from the wild. Of the 28 reliable accounts of sightings of female leopards with kittens in Turkmenistan and Iran, 14 had one and 14 two kittens.

The gestation period in captivity is 96 (90–105) days and should be similar in the wild. Interbirth intervals recorded in Africa were on average over two years (Schaller 1972, Bailey 1993). Animals reach sexual maturity at 2–3 years and can live up to 20 years (Nowell & Jackson 1996). Young leopards become independent at the age of 13–18 months. Siblings may remain together for sev-

[2] *P. p. saxicolor* is a synonym to *P. p. ciscaucasica*, which has been described earlier. Against the general taxonomic rules, we here use saxicolor, as this name is used in the IUCN Red List.

eral months before separating (Skinner & Smithers 1990). Therefore, seeing tracks of two animals does not necessarily mean observing a mating pair.

Social and spatial organisation

A number of factors determine the size of a leopard's home range: abundance and distribution of prey animals, habitat, topography, and anthropogenic transformation of the landscape. There are no reliable information on home range size in the Caucasus. Nasimovich (1952) estimates 100 km^2, and Heptner & Sludskij (1972) interpret this as very large.

Studies across the leopard's range show that home range size varies greatly with prey density and habitat (Lukarevsky 2001, 2005). In their review, Marker & Dickman (2005) list individual home ranges from 9–388 km^2 for adult males and 8–487 km^2 for adult females. Large ranges were found in very arid areas and small ranges in tropical rain forest. Khorozyan (2003a) tried to estimate leopard density based on the number of scats found per km of inspected trail. He made a comparison of nine studies from Africa to India and found a significant relationship between a faecal relative abundant index and the actual leopard density. Based on this relationship, he estimated a leopard density in Armenia of 0.4 leopards/100 km^2, which is at the low end of known leopard densities (Khorozyan 2003a, Marker & Dickman 2004).

Anecdotal observations indicate that adult males usually live entirely or partially on the territories of two or three adult females (Pikunov & Korkishko 1992, Lukarevsky 1993, 2001). In contrast to females, adult males are more mobile and often change their hunting grounds. They remain in an area only if young males show signs of territoriality, or if a female is in oestrus. In such cases the resident male traverses nearly all of the trails and walks along all of the ridges and puts special effort into marking the territory with scrapes. When the females are in heat, their behaviour changes significantly, including their use of territory. Observations indicate that leopard females actively search for males, intensely marking their territory. In this period, both males and females patrol almost their entire territory, and cover the heart of their ranges completely. Leopards use most frequently trails with a good view to move from one hunting ground to another. Such trails are located in places where a ridge offers a panoramic view of one or two, sometimes three or four ravines, and the visibility reaches up to several kilometres. Besides acting as observation points, mountain ridges also allow an animal to travel quickly through a territory. Leopards prefer well-travelled paths also used by other animals or men, and even roads (Lukarevsky 2001, 2005).

Fig. 4. Kavkasky Zapovednik in the Russian part of the Greater Caucasus (Photo WWF, F. Mörschel).

Diet

According to Heptner & Sludskij (1972), wild ungulates – bezoar goat, tur, mountain sheep, chamois, roe deer, red deer and wild boar – constitute the main prey of leopards in the Greater and Lesser Caucasus. Sometimes they also catch European hare, pheasant, rock partridge, black grouse, snow cock and porcupines. Where wild ungulates are abundant, almost no attacks on domestic animals occur, but from areas with low wild prey density, predation on cattle, sheep, horses, donkeys, dogs and poultry are reported.

Lukarevsky *et al*. (2004) identified for the Lesser Caucasus and the eastern part of the Greater Caucasus bezoar goat, wild boar and roe deer as most important prey species, and for the western part it used to be wild boar, red deer and roe deer. Leopard prey on many different species in the Caucasus eco-region, but the predator significantly depends on the populations of a few small to mid-sized ungulates. The leopard's primary prey in the Caucasus eco-region also include mountain sheep, tur, red deer, chamois, and livestock. The analyses of 74 scats collected in the vicinity of Nyuvadi village on Meghri ridge in Armenia 2004-2006 showed that wild boar was the staple food in southern Armenia (Table 1).

Table 1. Diet of the leopard in the vicinity of Nyuvadi village on the Meghri ridge, Armenia, based on scat analyses.

Prey item	n	%
Wild boar	32	43.2
Porcupine	8	10.8
Bezoar goat	7	9.5
Roe deer	2	2,7
Badger	2	2,7
Fox	1	1,4
Horse (foal)	7	9,5
Unidentified	10	13,5
Vegetation	5	6,8
Total	**74**	

Habitat

In the Greater Caucasus Mountains, the leopard resides in subalpine steppe-covered meadows, deciduous and mixed forests and dense shrub vegetation. As a rule, leopards live near slopes and rock outcrops (Heptner & Sludskij 1972). More important than the vegetation cover is the presence of a sufficient number of ibex, tur, chamois, deer,

Fig. 5. Araz/Araks river valley at the border between Azerbaijan and Iran (Photo E. Askerov).

and wild boar, as well as areas with limited snow cover in winter, as snow negatively affects not only the distribution of prey, but also the leopard itself. Nasimovich (1955) wrote the most detailed description of the distribution of the tur - one of the leopard's primary food sources - with respect to snow accumulation. However, the relationship between snow cover, leopard presence and the behaviour of large ungulates is not fully understood; there have been only anecdotal reports and observations for the past 50 years.

In winter, the western part of the Greater Caucasus is covered with a deep layer of snow, which can reach several meters in Kavkazsky Zapovednik (Fig. 4). Such severe conditions hinder movements of animals and, to a significant extent, hinder the leopards to hunt wild ungulates.

In Dagestan, the leopard remains in the Andiskoye and Avarskoye Koisu regions (see chapter 3), where the jagged slopes of ravines are covered with forest and snow rarely lasts more than three to five days and disappears within a day on slopes with southern exposition. These slopes are covered with mixed, broadleaf, and coniferous forests. In broadleaf forests birch, beech, and oak dominate, depending on elevation, exposition, and steepness. Wild boars congregate at one or another place, depending on the season and productivity of the vegetation, for instance in oak-dominated forests. Roe deer – and occasionally bezoar goat – live in most of the habitats described. Animals that have secondary importance in the leopard's diet, such as hare, fox, and badger, are rather common. The most favourable habitats for the leopard in Dagestan are located in the Andiskoye Koisu basin, where – different from Avarskoye Koisu basin – the cats still find large areas not divided by towns and other anthropogenic features. In the Avarskoye Koisu basin, leopard habitat is significantly more fragmented and restricted to the lower part of slopes, two to three kilometres wide. The best habitat is found in Ingushetia and is, but only to the lesser part, located in Erzi Zapovednik. Here, we still find an area of 600–800 km², without a single town or village. The slopes of the Skalisty Ridge, covered with pine, beech, hornbeam, and oak forest, form a habitat favourable to many mammals, including leopard. These are the best leopard habitats in the Greater Caucasus.

Fig. 6. Old-growth forest in the Istisuchai River Valleyin the Talysh Mountains in Azerbaijan (Photo V. Lukarevsky).

In the Lesser Caucasus, habitats used by leopards are rather diverse. They use rocky ravines almost completely devoid of trees or shrubs (Zangezur Range, especially the southwestern slopes; Fig. 5), highland steppes, areas with sparse juniper or deciduous growth on steep ravines with wild ungulates such as bezoar goats and wild boar (Reserve, Bargushatsky and Meghri Ranges). Signs of leopards have been found from the foothills (600–800 m) up to 3800 meters above sea level (Mt. Gazangeldag; Lukarevsky *et al*. 2007).

In the Istisuchai River valley in the Talysh Mountains (Fig. 6), leopards live in steep ravines with old-growth forests (maple, beech, hornbeam, linden, oak, walnut, etc.) with rock outcrops and cliffs. Evidence of leopards was found in areas with good visibility and with high numbers of wild boar and roe deer. According to reports from local

hunters, roe deer density is 1–1.5 individuals/km², and according to Kuliev (2000), wild boar density reaches 10 individuals/km², a figure which appears too high to us. In the Talysh Mountains, where the forest understory is well developed, roe deer do not migrate during the snowy season, but eat from directly under the snow, forming a system of trenches. Rakhmanov Babakhan reported that he once found eight animals following such trenches. In the early 1900s the leopard was quite common in the Zuvand Basin of the Talysh, where its habitat was significantly different than in the Hyrcan forests. Here the leopard's habitats are nearly identical to those still preserved on the Meghri Ridge (Fig. 7) in Armenia and in the Qara-Dagh Mountains in Iran.

The critical habitat for the Leopard in the Khosrov Reserve in Armenia (Fig. 8) is sparse juniper forest (Khorozyan 2003b). Human activities are very limited in the Khosrov Reserve area, where all villages were abandoned, although the area is still used as summer pastures for livestock. On the other hand, the Gndasar Mountain and Noravank Canyon area contains high road density and 13 inhabited villages with high human and livestock numbers. This area is a vital movement corridor for leopards and other wildlife between Khosrov Reserve and southern Armenia, and also to northern Iran where significant numbers of leopards live (see chapter 3).

In Iran the leopard's habitats are rather diverse and range from almost treeless rocky ravines (Kopet-Dagh, Parapamiz, Qara-Dagh, Kiyamaki Dagh and Marakan Mountains, as well as nearly all of the Iranian highlands) to steppe highlands and hills in Marakan Reserve (Fig. 9). Other areas are covered with sparse juniper and deciduous forests on steep slopes where wild ungulates – bezoar goats and wild boars – live (Arasbaran Reserve, Talysh Mountains). Evidence of leopards has been found from the lowlands (600–800 m) up to 2,400 meters above sea level (Daradiz and Kyiamaki Mountains).

Fig. 7. Meghri range in southern Armenia (Photo WWF, F. Mörschel).

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Fig. 8. Khosrov Reserve in Armenia (Photo K. Manvelyan).

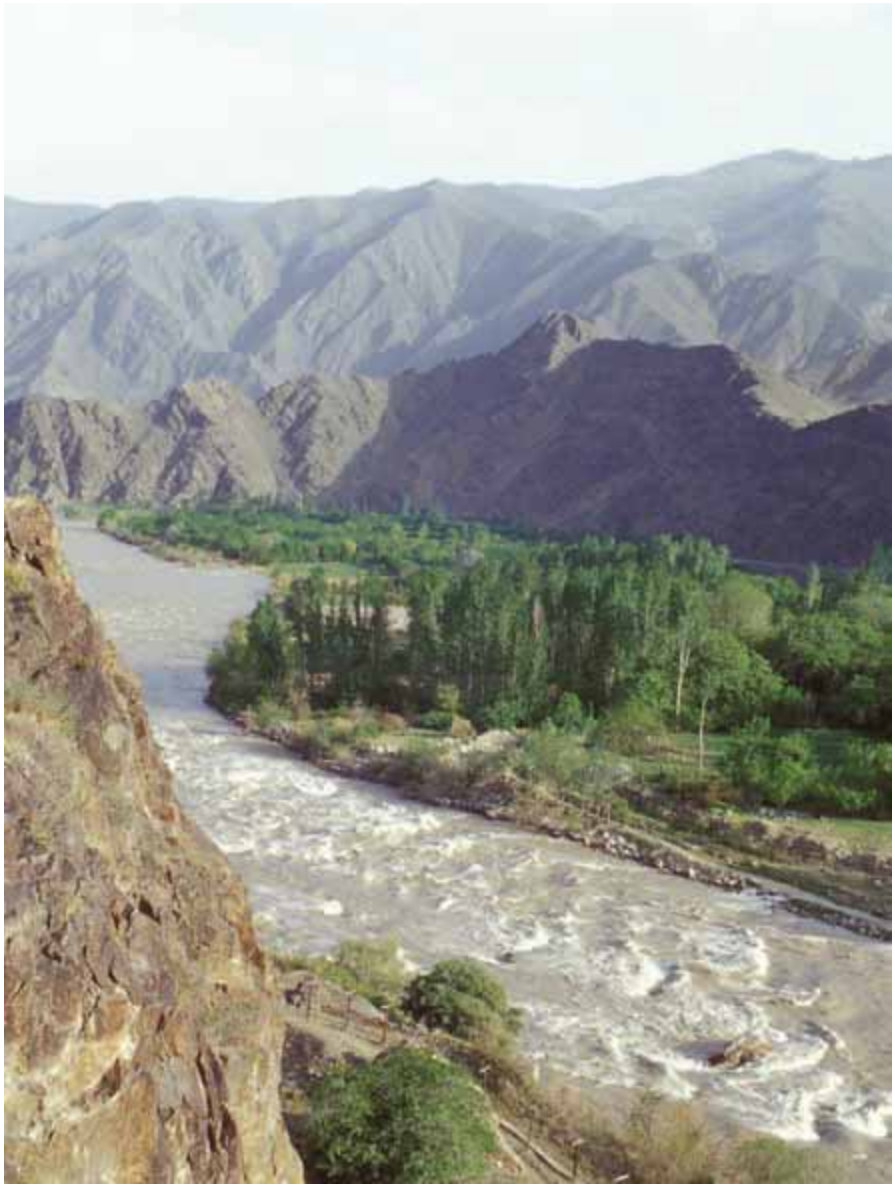

Fig. 9. View from southern Armenia across the Araz/Araks river towards Iran (Photo WWF, F. Mörschel).

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Status of the Leopard in the Caucasus

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There has been a huge decline in the former range of the leopard in the Caucasus, which is estimated to have once covered the whole region, except for steppe areas. More recent surveys, including those conducted by WWF since 2001 and others, based on searches for field signs, camera trapping and questionnaires have clarified the situation to some degree. These surveys have confirmed some surviving nuclei and identified possible sites and promising areas for further survey. The largest populations in the ecoregion survive in Iran, which seems to be a stronghold for the leopard in the region. The current presence of leopards in NE Turkey is not confirmed. Leopards have disappeared from the western part of the Greater Caucasus and are known from very few localities in the east. A few occurrences are known in the Lesser Caucasus, including Khosrov reserve and the mountain ridges along the border between south Armenia and Azerbaijan. Existing sites are fragmented and estimated numbers are very low, even down to a single animal in one case. Tentative estimates indicate not more than 15 leopards in the Greater Caucasus and up to 50 in the Lesser Caucasus and Iran. The viability of these small remnants, and the extent to which they are dependent on immigration from Iran is not known.

Assessing the status and the trend of a population is the obvious first step towards its conservation. In the case of the leopard in the Caucasus, this is however a challenging endeavour. There can be no doubt that the leopard is highly endangered – this was already the verdict of Heptner & Sludskij (1972) for the early 1970s and has been corroborated by all subsequent reviews – but how many leopards are left, where exactly, and whether the nuclei are still viable or not is matter of debate and speculation.

Leopards are elusive animals living at very low densities in remote and often hardly accessible areas. Marginal or non-existing capacity in wildlife management and research in all Caucasian countries are responsible for a shortage of data and limited understanding. Recent reviews of the status of the leopard in the Caucasus suffer from the lack of reliable information and are often based on unconfirmed or anecdotal reports. Many of these observations are impossible to judge and seem to have been included over-enthusiastically into the published reports. In recent years, several field surveys based on traditional field techniques were carried out, mainly on behalf of WWF, and researchers have started to use camera traps and ventured into molecular and chemical methods to generate confirmed leopard presence data. These efforts have produced some spectacular, though mostly anecdotal results. The vast extent of the Caucasian range and the arduous access of remote areas make a systematic survey or a continued monitoring a very difficult task, even without considering the organisational and logistic challenge arising from the fact that six different countries share the eco-region. In this article, we summarise recent reviews, surveys, and field research. As none of the surveys were exhaustive, we present and discuss not only confirmed, but also possible occurrences. In addition, we indicate which areas outside the known or probable present distribution areas of leopards in the Caucasus might be promising for further survey work.

Methods

The main methods used to confirm the presence of leopard in the Caucasus were compiling information from local people and systematic search for field signs (Lukarevsky 2003, Lukarevsky *et al*. 2004a). Such signs are footprints, scrapes, scats and urine marks. Detection of signs depends on the observer's experience, but also on vegetation, substrate, and humidity. Blurred signs of any of the larger carnivores (e.g. brown bear, wolf, hyena) can be confused with leopard, but for distinct cat footprints in the Caucasus, only large Eurasian lynx overlap in size with small leopards. The most distinct sign for the species are the *scrapes* made by the hind paws and about 35 – 50 cm long (Fig. 1). In August and September 2001 a first series of 32 transects with a total length of 419 km were carried out (Lukarevsky *et al*. 2004a) in Armenia (14 routes, 190 km), Georgia (7 routes, 100 km) and Azerbaijan (11 routes, 129 km). A follow-up survey took place in July and August 2003 in Armenia and Azerbaijan (Lu-

Table 1. Leopard field surveys (transects) in the Caucasus done by V. Lukarevsky and co-workers from 2001–2005. Transects: total = number of transects made; pos = number of transects with leopard signs; length = sum of kilometer walked, ridden or driven.

Year	Country	Period	Area	Transects		
				total	pos	length
2001	AM	25.07.–10.08.	Khosrov NR	14	7	190
	AZ	15.08.–06.09.	Talysh, Zangezur	6/7	2/2	129
	GE	15.–23.09.	Assa river, S of Ingushetia	7	0	100
2002	RU	06.–18.08.	Greater Caucaus (Kabardino-Balkariya, Karachaevo-Cherkesiya, Kavkazskiy zapovednik)	14	0	205/500
	AZ	28.05.	Talysh Mountains (excursion)	1	1	15
	AM	22.–23.05.	Hosrov – Meghri (excursion)	1		7
	AM	11.–22.10.	Meghri, Hosrov	7	1	85
2003	AM	17.–29.07.	Nyuvadi, Meghri	8	1	97+
	AZ	02.–15.08.	Talysh, Nakhichevan, Zangezur	8	3	156+
2004	AM	10.–20.08.	Khosrov, Meghri, Shikahoh, Zangezur	9	4	135
	GE	30.07.–06.08.	Greater Caucasus (Tushetiya)	4	2	57
	IR	25. –26.4.	Lisar PA, Arasparan PA, Kiamaki PA, Marokan PA	9	64	106/400
	TR		Ikizdere and Sivirikaya, basin of Choroh (Ĉoroch) river (Kiliçkaya, Cevreli, Yusufeli)	7	0	60
	RU	07.–22.10.	Greater Caucasus (Dagestan)	9	2	103/370
2005	RU	03.–15.07.	Greater Caucasus (Kabardino-Balkariya, Kavkazskiy zapovednik)		0	>200
	AZ	5.–15.05.	Zakatala PA, Ilisu PA, Ahar-Bahar range	7	2	123/250

karevsky 2003), with 8 routes each in Armenia and Azerbaijan, of which 3 in the Talysh Mountains (southeast AZ, bordering IR), and 5 in the Nakhchyvan enclave (Table 1). The fieldwork was done by V. Lukarevsky and a number of local co-workers on behalf of WWF and compiled in several internal reports and summarised in an unpublished draft conservation strategy (Lukarevsky *et al*. 2004b). Additional field surveys were done in Iran (January/February 2004) in the Russian part of Dagestan (November 2004), on the Iori-Mingechaur plateau (May 2005), and in Talysh and Akhar-Bakhar ranges, in Nakhchyvan and in southern Armenia (Meghri ridge; March 2007). In the Russian part of the Caucasus, a questionnaire survey was carried out. Some 4,500 questionnaires were distributed, including 1,000 in Chechnya and Ingushetia. However, only about 80 were returned, and only an insignificant number of respondents passed on information that was previously not available. The results presented here are based, if not stated otherwise, on these reports and the summary. Additional transect surveys were done by Khorozyan *et al*. (2005) in 2004 in Khosrov (94 km) and in Shvanidzor-Nuvadi (95 km) areas of Armenia with the intention to collect leopard scats.

Fig. 1. The typical sign left by leopards are scrapes made by the hind paws (Photo V. Lukarevsky).

During the field surveys, local people were interrogated. Information gathered that way was often included into the reports, but so far never systematically analysed and compiled. There is no comprehensive large-scale survey based on standardised interviews available that would allow assessment of the potential presence of the leopard based on the knowledge of local people. Camera trapping has produced positive results in three places (AM, AZ and GE) so far, but was not applied in a manner allowing a quantitative assessment. Radio telemetry has never been used to study leopards in the Caucasus ecoregion.

Status of the leopard in the Caucasus

Historic distribution

Heptner & Sludskij (1972) have reconstructed the historic distribution of the leopard in the Caucasus (Fig. 1). The range covered the whole of the Greater and Lesser Caucasus except steppe and semi-desert areas. Considering the habitat south of the border of the Soviet Union, the species was probably widespread in the mountains of northern Turkey and Iran. "By the 1950s to the 1960s the range of leopards in the Caucasus had shrunk greatly, the population of the animal became negligible, and actually on the brink of total extinction." By 1950, Heptner and Sludskij (1972) indicate only three remaining nuclei (Fig. 2), with still decreasing tendency: "On the whole, by the middle and end of the 1960s leopards had already practically disappeared or were passing through their last days in the Trans-Caucasus and the Little Caucasus. They still occur, though very rarely, at places where

there are several tributaries from Iran, i.e. on the Zangezur (southeastern AM and southwestern AZ) and persist on the Talysh (AZ)." In the Greater Caucasus, leopards were still met along the southeast slope (triangle RU, GE and AZ – Fig. 2) and "some strays" in the Kuban catchment (northwestern nuclei in Fig. 2). In 1972 the leopard was granted protection in the Soviet Union, and the Caucasus population was listed under Category I in the Soviet Red Data Book and considered immediately threatened with extinction. There is very little published information on the leopard in the Caucasus after 1970 until recent times. Shoemaker (undated) speculated for the early 1990s that there were probably no more than 10 individuals living in the Greater Caucasus. It was debated whether they were a persisting nucleus or immigrants from the south. A vital population however remained in the Lesser Caucasus, in the southern parts of Armenia and Azerbaijan, obviously profiting from animals immigrating from the south. Based on harvest rates, Khorozyan (1999) illustrated an increase and north-expansion of the leopard population in Armenia in the years immediately before its legal protection in 1972. The development of the Iranian source population is however not known.

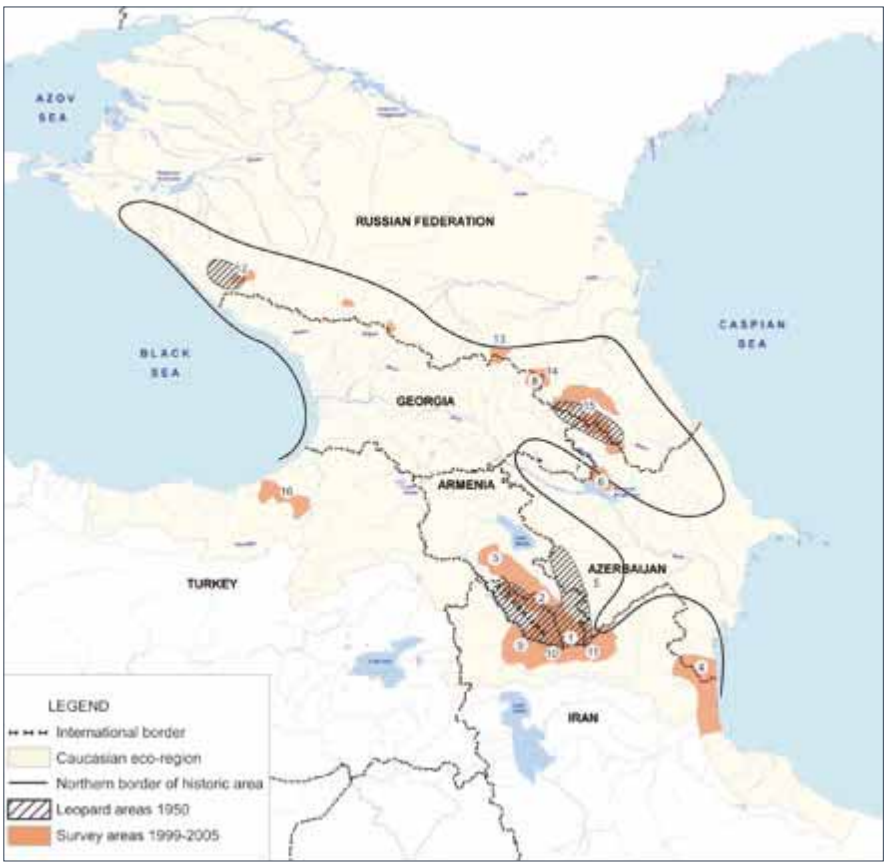

Fig. 2. Historic range of the leopard (areas south of the solid line) and leopard distribution in the Caucasus by 1950 (crosshatched areas) according to Heptner and Sludkij (1992). In orange the survey areas 1999–2005 (results in Fig. 3). Black numbers in white circles: Areas and locations mentioned in the text: 1, Meghri Range; 2, Zangezur Mountains; 3, Khosrov Reserve; 4, Talysh Mountains; 5, Karabakh and Murov-Dagh Mountains; 6, Ilisu Branch Reserve; 7, Vashlovani Reserve; 8, headwaters of Andiyskoye Koysu River (Tushetis Nature Reserve); 9, Marakan Protected Area; 10, Kiyamaki Dagh Reserve; 11, Arasbaran Biosphere Reserve in Qara Dagh; 12, Caucasus State Biosphere Zapovednik; 13, Armkhi and Assa headwaters (Ossetiya and Ingushetiya); 14, Sharoargun and Argun headwaters (Chechenya); 15, Adiskoye Koysu and Avarskoye Koysu headwaters (Dagestan); 16, Ikizdere and Sivirikaya, basin of Choroh (=Ĉoroch) river (Kiliçkaya, Cevreli, Yusufeli).

Armenia (AM)

An important region for the leopard in the Lesser Caucasus is southern Armenia (Fig. 3). The ranges occupied by leopard are the mountains southeast of Yerevan and south of Lake Sevan (Khorozyan & Malkhasayan 2005; Fig. 1). The best-known leopard area are southern Zangezur and Meghri Ranges shared by AM and AZ (1 in Fig. 2) in the southern tip of the country, where the estimation from the field surveys carried out by V. Lukarevsky and colleagues on behalf of WWF was 3–5 individuals (Lukarevsky *et al*. 2004a). The presence of the leopard in this region is also demonstrated by sporadic, but regular attacks on livestock, especially in the lower parts of the mountains. The Meghri occurrence is adjacent to the leopard range in Azerbaijan's Nakhchyvan Republic and in northern Iran. Another permanently occupied area is the Khosrov Reserve (2 in Fig. 2; 2–3 leopards). The Zangezur Ridge (3 in Fig. 2) and adjacent mountains form an ecological corridor and are a significant transit region between existing populations in NW Iran and the south Transcaucasus. Another important corridor between northern AM and the Karabagh Mountains (see also Zimmermann *et al*. 2007) is the Murovdag. These ridges form also the most important connection between the Iranian population and the Greater Caucasus. The large cat persisted in this region because of the proximity to the Iranian source population. The leopard has however been very rare since at least 1945; from 1949 to 1976, only 25 leopard skins were supplied to the Armenian state fur purveyance centres (Khorozyan 1998), so less than one per year. The leopard was granted legal protection in Armenia in 1972. No specific surveys were done until recently, but we can assume that the occurrence persisted at relatively low abundance. The total estimate for the late 1990s was not more than 25 leopards (Khorozyan 1998). More recent reports estimate the total number of leopards in Armenia to be 7–11 individuals (Lukarevsky *et al*. 2004b) and 10–15 leopards (of which 5–8 adults; Khorozyan & Malkhasayan 2005), respectively. Even the lower figure may have been too optimistic, and the number of leopards in southern Armenia in 2001–2003 may have been as low as 3–5 individuals. In the following years, increasing reports and observations indicate higher leopard presence (up to 7 animals).

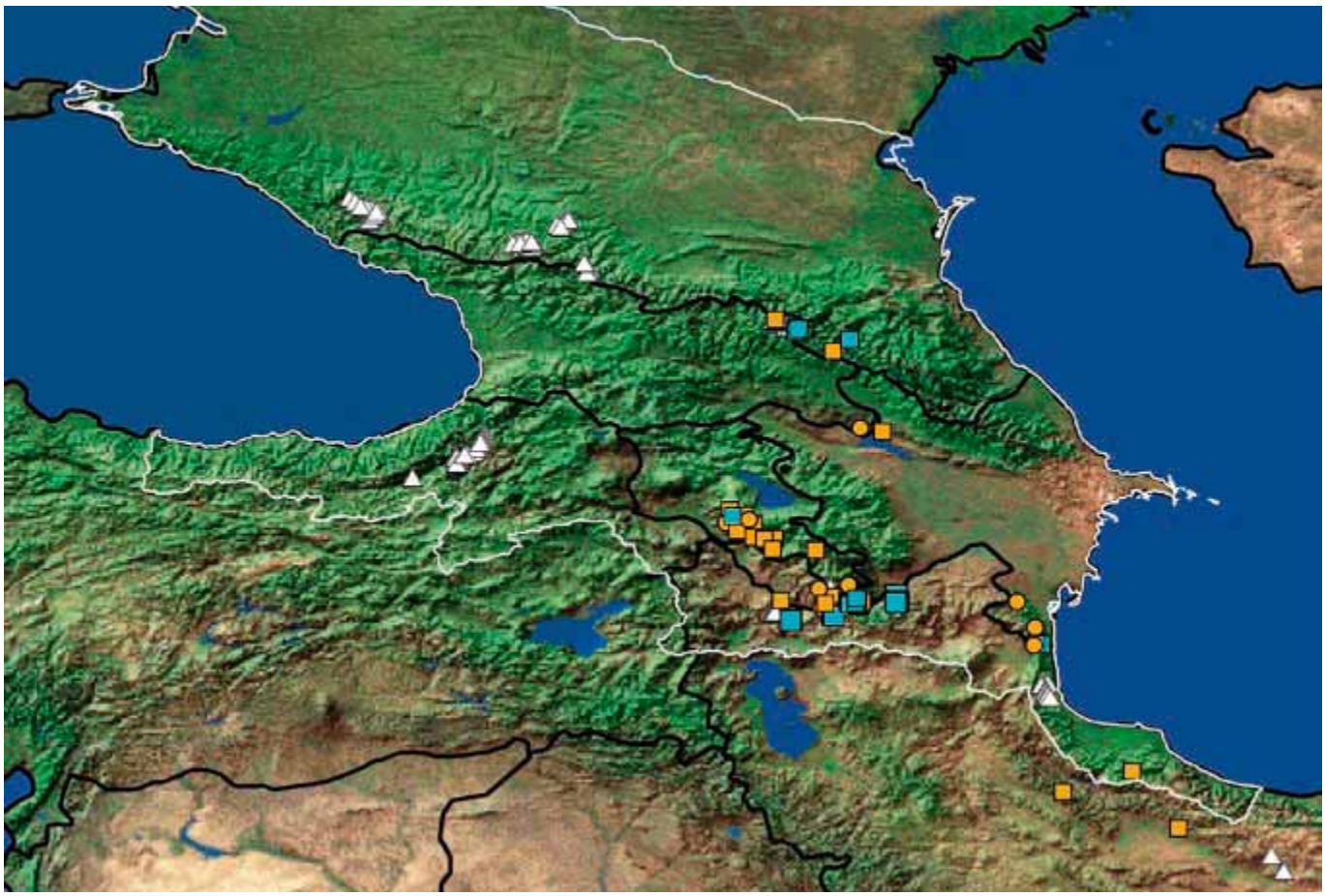

Fig. 3. Recent surveys and distribution of the leopard signs in the Caucasus eco-region. Blue squares indicate the transects with leopard signs carried out by V. Lukarevsy and co-workers on behalf of WWF from 1999–2005, white triangles indicate the locations of negative transects. Orange symbols represent leopard presence indication from the literature or other reports (e.g. questionnaires) since 1990. Dots are the "hard fact" observations (such as dead leopards or camera trap pictures), squares other confirmed records (e.g. tracks).

Fig. 4. Leopard in the Talysh Mountains pictured by an automatic camera in January 2007 (photo E. Askerov).

Azerbaijan (AZ)

Leopard was legally protected in Azerbaijan in 1969, but information about leopards in Azerbaijan remains limited. During the surveys, four separated occurrences were identified: Talysh Mountains (4 in Fig. 2; Fig. 4) in the southern most corner of Azerbaijan. Signs of 3–5 leopard were found here at an altitude of 700–1500 meter. This occurrence is adjacent to the leopard range in the neighbouring ridges of Iran. In south-western Azerbaijan, in the Zangezur range (2 in Fig. 2; Fig. 5) of the Nakhchyvan Autonomous Republic, the distribution of leopard is consistent with its presence in Armenia and in Iran. The abundance seems to be low, probably not more than 3–4 animals. Difficult to assess is the presence of the big cat in the disputed area of Nagorny Karabakh. According to local contacts (Lukarevsky *et al*. 2004b), a leopard occurrence of probably not more than 3–4 animals persists

in the western part of the Karabakh and Murov-Dagh Mountains (5 in Fig. 2). Furthermore, some individual leopards exist in the Ilisu Branch Reserve (6 in Fig. 2) in the Iori-Mingechaur highlands (Fig. 5) of the Akhar-Bakhar ridge in northern Azerbaijan. This occurrence is in the Greater Caucasus and is interesting in regard to its potential connection with adjacent leopard areas in Georgia and Russia. This area needs special investigations, as individuals migrating from the Greater or Lesser Caucasus might occur here. Field surveys in March 2007 have confirmed leopard presence in Meghri mountains and on the Zangezur ridge on the Azerbaijan side (but no sign was found on the Armenian side), in the Negramdag at the border with Iran, in the Iori-Mingechaur and the Akhar-Bakhar ridge.

Fig. 5. Victor Lukarevsky (front) and Elshad Askerov looking for leopard signs in the Turianchai Reserve in the Iori-Mingechaur highlands of the Akhar-Bakhar Range in northern Azerbaijan (Photo E. Askerov).

Georgia (GE)

In April 2004, the NACRES team took a picture of a leopard (Frontispiece) by means of a remote-sensing camera in the Vashlovani State Reserve (7 in Fig. 2) in southeast Georgia (Anonymous 2004). NACRES biologists Bejan Lortkipanidze and Georg Darchiashvili had discovered leopard tracks in the reserve already in winter 2003. The first picture of a leopard from Georgia ever was nevertheless a sensation. The last evidence of a leopard in Georgia was an animal killed in 1952! The picture is also remarkable because it was taken in the Shirakis Vake, a rather arid, low, but rugged ridge of only about 500 meters altitude covered in dense Juniper-Pistacia scrub forest, forming a good, but small and isolated patch of leopard habitat south of the Greater Caucasus. The unexpected presence of a leopard in the Vashlovani Reserve can however not disguise the fact that there is very little evidence for the presence of the species for decades.

The survey has revealed only one more place where leopard signs were detected, along the headwaters of the Andiyskoye Koysu River in Tushetia (Fig. 3; 8 in Fig. 2), at the border with Russia's Dagestan. It is impossible to estimate the number of leopards in Georgia. If there are any resident animals, they must be very few. In 2000, NACRES members saw the skull of a leopard killed in Arkhoti (the upper part of the Assa River basin) in the 1980s (Lortkipanidze *et al*. 2004). A WWF expedition to the area in 2001 did not find clear evidence of leopard presence, although local hunters said that they sometimes saw leopards (Lukarevsky *et al*. 2003). However this expedition was of short duration and survey conditions in Arkhoti are difficult. Leopard presence was recorded farther down the Assa River valley in Ingushetia (RU) in 2002–2005 (see below). Its occurrence in the Georgian part of the Assa Valley is considered to be equally likely. The habitat is suitable – inaccessible slopes, presence of turs, and minimal disturbance as very few people live in this area.

Iran (IR)

According to Firouz (1974) the leopard was widespread in northern Iran and present in most of the protected areas of the region. Close to Armenia and Azerbaijan, the species was found in Lake Orumyieh National Park[1], Marakan Protected Area (9 in Fig. 2) and Kiamaky Wildlife Refuge (10 in Fig. 2). Tajbakhsh (1995) and Ziaie (1996) stated that the leopard was still to be found in most of the Iranian provinces, well preserved in reserves, however persecuted outside the protected areas. Kiabi *et al*. (2002) confirm the wide distribution of the species, with the main distribution area – and probably the only vital population – along the Alborz (Elburz) range south of the Caspian Sea, stretching from Azerbaijan in the west to Turkmenistan in the east. They roughly estimated the Iranian population to be 550–850 leopards, of which 55 % inside protected areas. The highest abundance was in the northwest of the country, adjacent to or within the Caucasus eco-region. This estimation however is based on data collection over 25 years. Newer estimations, based on recent field trips to protected areas in northwest Iran (Lukarevsky *et al*. 2004c) indicate lower numbers than claimed by Kiami *et al*. (2002): Marakan PA, 2–3; Kiamaky Reserve and surroundings, 10–12 individuals; Arasbaran Biosphere Reserve in the Qara Dagh (11 in Fig. 2), 7–9 leopards; Lisar Biosphere Reserve, sporadic. The total estimation for northwest Iran (3,000 km²) was not more than 25 leopards (Lukarevsky *et al*. 2004c). However, Lukarevsky *et al*. (2004a) state that the suitable habitat stretches most often far beyond the protected areas and leopards could well live in between the reserves, if wild prey would be sufficiently available and the leopards could be protected from illegal killing. No recent survey

[1] This is a surprising statement, given the fact that Lake Orumyieh NP is an open salt plain, a habitat that would have more suited the now locally extinct cheetah.

data are available for the Iranian side of the Talysh range (4 in Fig. 2). The mountains south of the border with Azerbaijan to the city of Rasht is an important area for leopard conservation, as it is the potential corridor between the populations in the Lesser Caucasus and the Alborz Mountains.

Russia (RU)

The northern foothills of the Greater Caucasus in the Russian Federation were the northern boundary of the historic distribution of the leopard, which was, by 1950, reduced to two small pockets and at the brink of extinction (Heptner & Sludskij 1972; Fig. 2). In the 1960s, "in the Great Caucasus some leopards are evidently still met with along the southern slope of the eastern section (Azerbaijan and eastern Georgia) and some strays probably live in the Kuban region of the Caucasus and on the southern slope of the western half of this range" (Heptner & Sludskij 1972), hence the authors seem to have considered the leopard virtually extinct in the Russian part of the Caucasus by 1970. However, the great cat persisted also in the north part of the Greater Caucasus in very low numbers. In the mid-1980s, "according to recent estimates, the number of leopards in the northern macroslope of the Greater Caucasus hardly exceeds 10 individuals. They are scattered over the vast space of the Krasnodar and Stavropol Provinces, and of the Kabardin-Balkar, Chechen-Ingush, and Daghestan ASSR" (Bragin 1989). The picture has not much changed until today.

The northwestern most occurrence, in the region of today's Caucasus State Biosphere Reserve[2] (12 in Fig. 2), is obviously extinct; no more signs of presence were discovered in the recent surveys (Fig. 3; Lukarevsky *et al*. 2004b). During the field transects from 2002 – 2005, signs of presence of leopards were still discovered in or reported from three places: In Ingushetia (Assa River valley) and Ossetia (Armkhi River) (13 in Fig. 2) and in Dagestan (Andiskoye Koysu and Avarskoye Koysu headwater systems; 15 in Fig. 2), where Yarovenko (1997) estimated that 10 leopards were living. The questionnaire survey in Chechnya revealed leopard presence along the headwaters of Sharoargun and Argun River (14 in Fig. 2). In spring 2002, a female with two cubs was killed in this region. The cubs were sold to Novosibirsk Zoo. The locations of the positive field transects are shown in Fig. 3. The abundance of leopards in the northern Greater Caucasus is however very low. All together, not more than 10 individuals are believed to live in the Russian part of the range.

Turkey (TR)

North-east Turkey was the western extent of the historic distribution of the Caucasus population of *P. p. saxicolor* (Fig. 2), but its presence in the Turkish part of the Caucasian eco-region has been questioned for at least half a century. Already Kumerloeve (1975) does not list any records of leopard from NE Turkey. In a recent review on the status and distribution of the leopard in Turkey and the Caucasus, Johnson (2003) concluded that population relicts still exist in the mountain ranges of northern Turkey. This assessment was based on only two recent reports, a track found in the snow of the Kackar Mountains (Samli 2003 on www.wildlifeeasy.com cited in Johnson 2003) and two sightings (of which one supposedly documented by pictures; Gulas 2003 on www.cemalgulas.com cited by Johnson 2003). Baskaya & Bilgili (2004) claim to have found leopard tracks at 16 of 46 field trips to the Çapans and Karçal Mountains (Eastern Karadeniz Range) between 1995 and 2001. The authors assumed an almost continuous range of leopards over 250 km from the Ikizdere-Ispir highway to the border with Georgia (where, on the Georgian side, no confirmed leopard occurrence exists). However, this interpretation is based exclusively on the finding of footprints, which are not unproblematic records in an area, where, with the Eurasian lynx, another large cat roams. During our field trip in the Turkish part of the Caucasus eco-region (Ikizdere and Sivirikaya, and Kiliçkaya, Cevreli and Yusufeli in the basin of the rivers Choroh (Çoroch); 16 in Fig. 2; Table 1) in 2003, we were not able to confirm the presence of leopard in north-eastern Turkey (Fig. 3). All droppings/faeces collected as potential leopard scats, including samples from north-eastern Turkey, proved to be lynx (and one dog) in DNA analyses (Can 2004). In spite of several optimistic publications in recent years, there was no hard evidence for the presence of leopard in the Turkish part of the Caucasian eco-system for decades (Can 2004). The habitat in north-eastern and eastern Turkey would however be suitable for the species (Zimmermann *et al*. 2007), and the area remains interesting for further surveys – mainly the regions bordering Armenia and Iran – but more decisive and robust monitoring methods will be needed.

Assessment and conclusions

It is difficult to make a comprehensive assessment of the status of the leopard based on the available publications and recent surveys. The Caucasus eco-region is a vast, very diverse and politically complicated area, and many of the places where leopards may still exist are extremely remote. No exhaustive survey was done so far; even the recent field trips had to concentrate on certain promising areas because of practical limitations. The published evidence seems partly over-optimistic, based on observations that were not confirmed as leopard signs, but on the other hand, once in a while a leopard is discovered in an area where it would not have been expected, like the photo-trap picture in 2004 from Georgia. However, there can be no doubt that the leopard in the Caucasus is critically endangered. The recent surveys on behalf of WWF (Fig. 3; Table 1) have confirmed the presence of the species in several locations scattered over the whole range, but the estimated numbers are very low, probably less then 15 for the Greater Caucasus and maybe up to 50 leopards for the Lesser Caucasus, including the cats in Iran, which seem to be the stronghold of the whole population. Even if the estimates are rather conservative or the odd leopard may have been missed, it is unlikely that important occurrences of the species are unknown. During the brief visits in Armenia and Azerbaijan in March 2007, less signs were found than in previous years, and new rumors on poaching confirm that the leopard is still under big pressure.

[2] The reintroduction of leopard into the Caucasus State Biosphere Zapovednik is presently discussed among Russian GOs, NGOs, and scientists.

The leopard is a long living and elusive animal, which can go undetected for some years in remote areas. However, over time, a species does not survive as individuals, but as a population with reproduction and mortality, and leaves an imprint in its environment. The presence of a population of large carnivores is normally well known to local people and should be particularly obvious in areas with good snow cover in winter, as in the Greater Caucasus. The absence of a species cannot be proven. However, if over an adequate period of monitoring, taking into account the lifespan and turnover of the leopard, no undisputable positive sign of presence confirms its presence, we can assume it is locally extinct. This is for instance the case in Turkey, where the last known leopard was killed in 1974 (which might even have been an escaped animal; Can 2004), but also for other regions in the Caucasus. Nevertheless, some areas in the eco-region remain to be surveyed, because there is a certain chance that leopards may have survived undetected because no adequate monitoring was established.

The absence of a consistent monitoring makes it also difficult to assess the trend of the population. The general belief is that the population is declining, but there is no evidence for this assumption. Heptner & Sludskij (1972) were very pessimistic regarding the survival of the leopard in the late 1960s, fearing its fast eradication in the Caucasus. If their assessment was correct, the leopard population has not continuously declined over the past 40 years, but at least temporarily recovered. The Kuban occurrence (number 12 in Fig. 2) went extinct, but the leopard has persisted in the eastern part of the Russian Caucasus. The situation stabilised in the Lesser Caucasus, but worsened again in the period after the disintegration of the Soviet Union. The Bezoar goat, the leopard's main prey, declined during the 1990s.

There can be no doubt that immigration from Iran was an important factor for the persistence of the Caucasus population, and probably not only in the Lesser Caucasus – where the connection between the occurrences in Azerbaijan, Armenia, and Iran is obvious – but also for the Greater Caucasus. We can assume that the species would indeed be extinct without sporadic immigrants from the south. As a matter of fact, the leopard has survived in both parts of the Caucasus even though it was considered "at the brink of extinction" already 50 years ago. This gives us at least some hope that conservation actions – if they start now – may not come too late, even though the population is at a dangerously low level and fragmented. The immediate needs or strategic goals are obvious: (1) stabilise the present occurrences, (2) secure the corridors to the Iranian populations (mainly in the Alborz range, which potentially connects the Caucasus population with the Central Asian populations), and (3) start to expand the present range of the leopard in the Caucasus in order to re-establish a viable metapopulation. One prerequisite for all conservation activities is however to complete the basic surveys in areas where leopards still might exist, and then to establish an efficient monitoring system, allowing us to assess the status and the trend of the leopard population and to control the effectiveness of conservation measures.

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Status of the Prey Species of the Leopard in the Caucasus

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The severe economic crisis that followed major political and social changes in 1992 in the former Soviet Union, together with a weakening of formerly effective protection systems resulted in a sharp rise in hunting of wild ungulates and exploitation of natural resources. As a consequence, turs, bezoar goat, wild sheep, chamois, red deer and roe deer have all declined in abundance over the past 15 years, their ranges have been reduced and in many cases are becoming fragmented. In Iran, the decline in ungulate numbers has taken place over a longer timescale, since 1978. The only ungulate species in the ecoregion that has been relatively unaffected is wild boar. The effects on smaller mammalian prey such as porcupines and hares are unknown. The precise extent of species declines is difficult to evaluate in many cases because of inadequacies in baseline data and lack of monitoring programmes. The best populations of ungulates survive in a few protected areas such as the Kavkasky, Khosrov, Kazbegi and Zakataly Reserves and remote areas of Dagestan. The extent to which fragmented and depleted prey populations at an ecoregion-wide scale can support viable leopard populations, and over what time scale, needs urgently to be assessed.

The leopard *Panthera pardus* has the widest distribution of all big cats and a very wide prey spectrum (Nowell & Jackson 1996). Within the Caucasus ecoregion, leopard prey includes an expected mix of large ungulates, medium sized mammals, small mammals, game birds and domestic livestock (Heptner & Sludskij 1972, Gutleb n.d, Khorozyan & Malkhasyan 2002).

For the former Soviet Union, Heptner & Sludskij (1972) said the main prey of Caucasus leopards consists of wild ungulates: bezoar goat *Capra aegagrus*; turs *Capra (ibex) caucasica* and *C. cylindricornis*; wild sheep *Ovis orientalis*; chamois *Rupicapra rupicapra*; red deer *Cervus elaphus*; roe deer *Capreolus capreolus*; and wild boar *Sus scrofa*. Sometimes they prey on European hare *Lepus europaeus*, snowcock *Tetraogallus caucasicus* and *T. caspius*, Caucasian black grouse *Tetrao mlokosiewiczi*, rock partridge *Alectoris chukar*, pheasant *Phasianus colchicus* and crested porcupine *Hystrix indica* (in Talysh). They also take livestock including dogs, poultry, horses, donkeys and cattle.

Gutleb (n.d.) said the main prey of the leopard in Iran is bezoar goat together with wild sheep and wild boar. Foxes, presumably *Vulpes vulpes*, dogs, cows, sheep, and horses are also taken.

In Armenia, bezoar goats make up over 90 % of leopard diet in Khosrov Reserve, with wild boar and hares taken occasionally. Small rodents are also consumed and berries of buckthorn *Frangula* sp. have also been recorded. In southern Armenia wild boar and roe deer are taken more often, and hare and porcupine are taken opportunistically (Khorozyan & Malkhasyan 2002, Khorozyan *et al*. 2005, Lukarevsky *et al*. 2007a).

In Turkmenistan this leopard subspecies has also been recorded preying on goitered gazelle *Gazella subgutturosa*. A number of small mammals and birds and even reptiles that could in theory be taken opportunistically are also present in the ecoregion.

Current Status of Prey Species

The severe economic situation and weakening of protection systems that have affected most of the region since 1992 caused a huge increase in exploitation of natural resources. Habitat destruction, overgrazing, and unregulated hunting of animals and collection of plants are three major and continuing threats to biodiversity in the ecoregion (Krever *et al*. 2001; Zazanashvili *et al*. 2004). Uncontrolled hunting for food or trophies has extirpated large ungulates from many areas. Overall numbers are now much lower than 20 years ago and surviving sub-populations are small and scattered. As a consequence, fragmentation has become an additional negative factor. In Iran, too, mountain ungulate populations have declined drastically, but over a longer time period, since 1978, and have become scarce as a result of poaching and increased use of protected areas by domestic livestock (Ziaie 1997, Kiabi *et al*. 2002).

The only species that may have escaped this onslaught is wild boar. Indeed, Gutleb (n.d.) suggested that a big increase in wild boar numbers in Iran might be a positive factor for the leopard in the region, and Lukarevsky *et al*. (2004) thought that good numbers in Talysh and other parts of the border area ensured a secure prey base for animals transiting from Iran.

Bezoar goat or Persian wild goat *Capra aegagrus aegagrus*. The species occurs in all countries of the ecoregion but numbers are much-reduced from former levels. Bezoar goats live on forested slopes on the northern side of the Greater Caucasus in Dagestan, Chechnya and Ingushetia (RU), Tusheti (GE) and an isolated population on Babadag (AZ; Fig. 3). Earlier reports of the species on the southern slopes of the Greater Caucasus have turned out to be erroneous. The population was estimated at 1,500 in the Greater Caucasus in the late 1980s (Weinberg *et al*. 1997). Highest numbers occur in Dagestan, where numbers in the second half of the 1990s were estimated at 1,500 (Wein-

berg 1999), while Nasrulaev (2003) gave a figure of 2,560 animals. However, Magomedov *et al*. (2001) estimated that between 1998 and 2000, the wild goat population in Dagestan might have shrunk by more than three times. Only about 100 remain in the Tusheti region, Georgia (NACRES n.d).

In the Lesser Caucasus, wild goats inhabit drier open habitats. In the late 1980s numbers were estimated at 2,000-2,500, with over half (1,000-1,250) on the southern part of the Zangezur range (Weinberg *et al*. 1997). Bezoar goat is still quite common in leopard range in Armenia (Fig. 1), especially Khosrov Reserve (Khorozyan *et al*. 2005) and also on the Meghri Ridge.

Bezoar goats are widespread in NW Iran in rocky terrain (Ziaie 1997) and are widely distributed in the mountains of NE Turkey (Kence & Tarhan 1997) though no population estimate is available for either of these countries. Bezoar goats are threatened by increased poaching for meat (Krever *et al*. 2001). They are included in the Red Data Books of Russia, Georgia, Armenia and Azerbaijan. Both the species, *C. aegagrus*, and the subspecies occurring in the ecoregion, *C. a. aegagrus,* were red listed as Vulnerable in 1996 (IUCN 2006).

Bezoar goats occur in Khosrov Reserve, and occasionally in Shikakhogh NR (AM); Ordubad Wildlife Sanctuary in Nakhchyvan and Gay-Gel Reserve (AZ); Tusheti Reserve (GE). They also occur in three protected areas in Iran along the border with Armenia and Azerbaijan: Marakan PA, Arasbaran PA, and Kiamaky WR.

East Caucasian tur *Capra cylindricornis* (Fig. 2) is distributed in the eastern part of the Great Caucasus from the Babadag massif in Azerbaijan to Mt Elbrus. It occurs in Azerbaijan, Georgia and Russia (Fig. 3; Kabardino-Balkaria, North Ossetia, Ingushetia, Chechnya, Dagestan). According to Weinberg *et al*. (1997) the population in the late 1980s had already declined by over 30 % to 18,000-20,000 though Magomedov & Akhmedov (1994) estimated 20,000 in Dagestan alone.

The tur occurs in the following reserves: Lagodekhi (200), Tusheti (700) and Kazbegi (3,000) (GE; NACRES 2006); Kabardino-Balkarian, and North Ossetian (about 800, RU); Zakataly (about 2000, though many of these cross regularly into Russia), Ilisu, and Ismailly (AZ). The large subpopulation (3,000) in Kazbegi NR in the Khevsureti region of Georgia is particularly significant, as a leopard skull was found here in the River Assa gorge in the 1980s (Lortkipanidze *et al*. 2004) and local hunters report that leopards are still present.

Fig. 1. Bezoar goats in Armenia (Photo A. Malkhasyan).

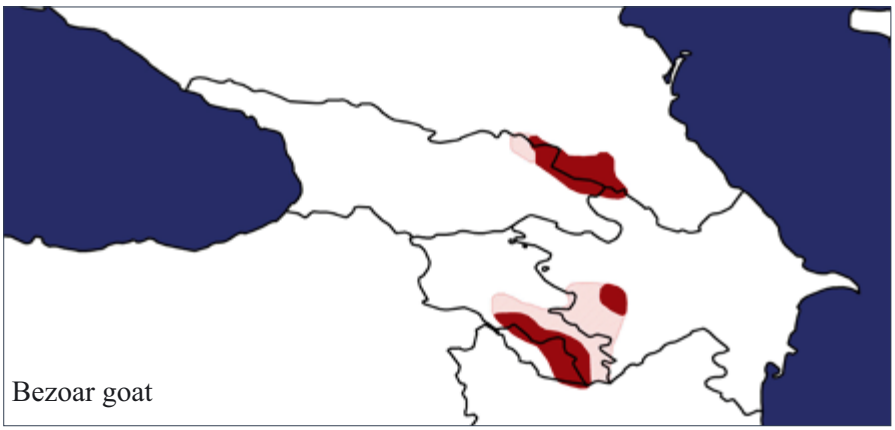
Uncontrolled hunting could pose a long-term threat to their survival and both species of tur have been hunted in the past for meat and trophies. In Georgia, tur-hunting plays a significant role in local culture, in Georgia (Khevsureti for *C. cylindricornis* and Svaneti for *C. caucasica*) and in the whole of the North Caucasus. Turs are legally protected from hunting in Georgia but are subject to trophy hunting elsewhere, though quotas and licensing agreements differ among the range states (Krever *et al*. 2001). Selective hunting has resulted in decreased proportions of males in most populations, even within reserves (Weinberg 2002a). *C. cylindricornis* was red listed in 1996 as Vulnerable (IUCN 2006).

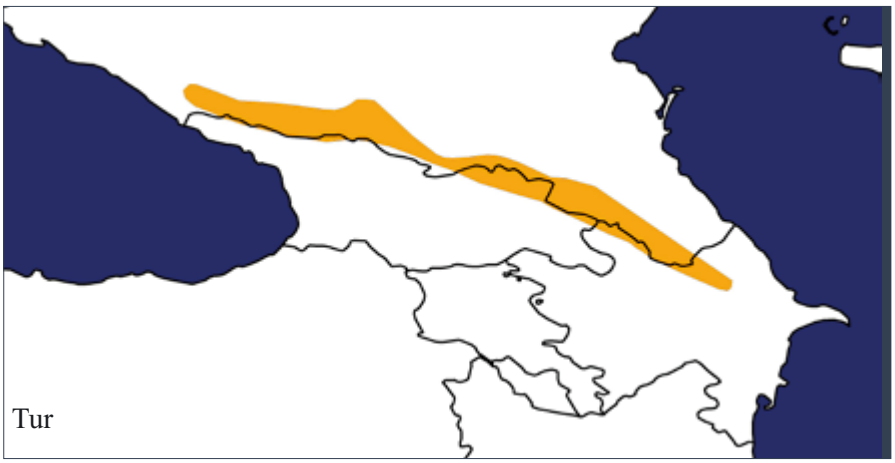
West Caucasian tur *Capra (ibex) caucasica* (Fig. 4) is distributed in the western part of the Greater Caucasus (Russia and Georgia). A small hybrid zone has been reported (Heptner & Sludskij 1972), but tur taxonomy remains uncertain and the relationship between the two taxa is unclear (Weinberg 2002b). Weinberg *et al*. (1997) estimated the total population at 12,000 and Krever *et al*. (2001) at 6,000-10,000. In 1980-1985, the Kavkasky NR alone harboured 5,000-7,000 tur, but by the end of the 1990s only some 2,500 remained (Romashin 2001). Approximately 1,000 occur in the Svaneti region of Georgia (NACRES 2006).

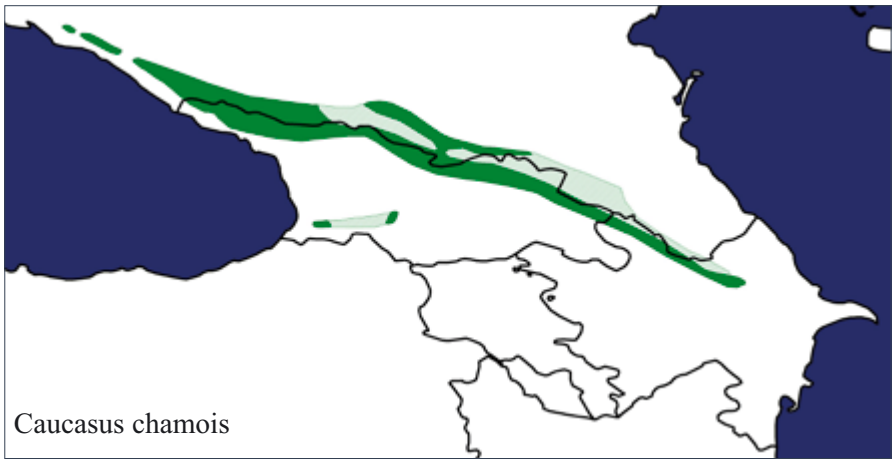
The tur occur in Kavkasky Reserve and Teberdinsky Reserve (RU) and a few along the border with Russia in Ritsa Reserve (GE). Red listed in 1996 as Endangered (IUCN 2006).

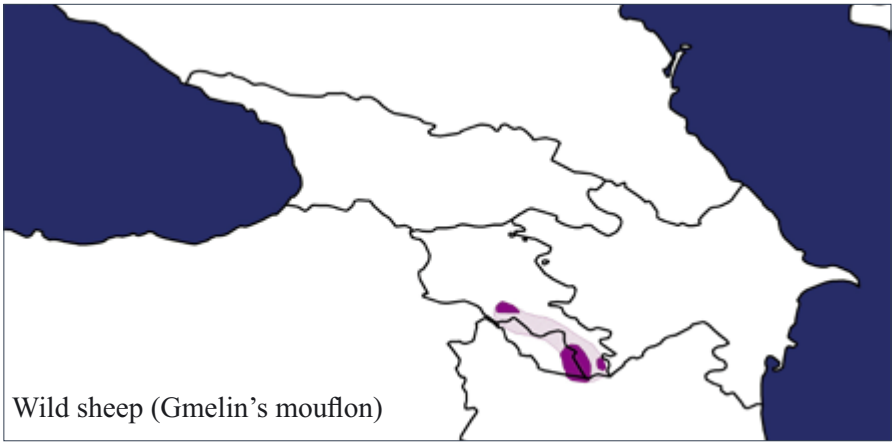
Wild sheep (Gmelin's mouflon) *Ovis orientalis gmelinii,* occur in the southern part of the Caucasus region, particularly the Zangezur range, Nakhchyvan,

Fig. 2. East Caucasian Tur in Lagodekhi Reserve, Georgia (Photo B. Lortkipanidze).









and NW Iran. Weinberg *et al*. (1997) said the population in the former Soviet Union probably numbered about 1,000. Current rough estimates are up to 500. In northwest Iran, wild sheep are widely distributed in foothills and rolling steppe and occur in three reserves on the border: Marakan Protected Area, Arasbaran Protected Area, Kiamaky Wildlife Reserve (Ziaie 1997). *O. o. gmelinii* was red listed as Vulnerable in 1996 (IUCN 2006).

Chamois *Rupicapra rupicapra* (Fig. 5). Two subspecies are recorded in the ecoregion. Caucasian chamois *R. r. caucasica* were once widely distributed along the Greater Caucasus, but along the North Caucasus numbers and population densities markedly decline eastwards. Weinberg *et al*. (1997) estimated the population at 15,000 in the early 1990s but numbers have decreased drastically in the last 20 years and are still declining and becoming fragmented. Krever *et al*. (2001) gave an estimate of 4,000–4,500 remaining in the Greater Caucasus (Russia, Azerbaijan and Georgia). Numbers in Lagodekhi NR (GE) fell from c. 350 in 1980 to 60 in 1990 and are still declining (Gurielidze 2004, NACRES 2004). Chamois have disappeared completely from the eastern half of the Lesser Caucasus and barely survive in the western part (Fig. 3); Krever *et al*. (2001) estimated that only c. 25 remain in Borjomi-Karagauli NP, GE.

In Azerbaijan, range and numbers have fallen sharply due to human influence in recent years. The population was estimated at 600–800, and is now restricted to the southern slopes of the Greater Caucasus in the area of Zakataly, Ilisu and Ismailly nature reserves (Gadjiev & Rakhmatulina 2000). Chamois are still quite common in Zakataly NR and current numbers may be 200-300.

Turkish chamois *R. r. asiatica* occur in the mountains of NE Turkey (Kence & Tarhan 1997) but no population estimate is available. Chamois do not occur

Fig. 3. Distribution of the larger prey species of the leopard in the Caucasus according to Weinberg *et al.* 1997. Solid areas = confirmed distribution, hatched areas = general distribution. The distribution areas in Iran and Turkey are not shown.

in Iran. The species is not considered to be globally threatened. Caucasian chamois was red listed as Vulnerable, and Turkish chamois as Data Deficient in 1996 (IUCN 2006).

Red Deer *Cervus elaphus*. Red deer were once widespread in the forests of the Greater Caucasus and also occurred in a few pockets in the Transcaucasus but are known to have declined over the past 15 years. Krever *et al*. (2001) reported several thousand in the Greater Caucasus with more than 1,500 in Kavkazsky NR in 1999, and less than 1,000 in protected areas in Azerbaijan, particularly Zakataly NR, and approximately 160 in Lagodekhi NR, Georgia. Numbers in Lagodekhi have declined from a high point of 1,434 in 1990, reached following suppression of wolves (Gurielidze 2004). Firouz (2005) said red deer once ranged through the forests of the northern Alborz but are now eliminated or extremely scarce in the western Caspian region. Red deer was globally red listed as Lower Risk/Least Concern in 1996 (IUCN 2006).

Roe deer *Capreolus capreolus* occur in all countries of the ecoregion and were formerly widespread across the former USSR (Heptner *et al*. 1961). Roe deer remain common all over the North Caucasus mainly in broad-leaved forests, though densities are not high, only up to 10/1000 ha. Roe deer occur widely in Georgia, including Lagodekhi and Tusheti NRs and the population in the mid-1990s was estimated at 3,000 (NACRES 1996). The species is also found in the Karadeniz Mountains of NE Turkey (Baskaya & Bilgili 2004). It was globally red listed as Lower Risk/Least Concern in 1996 (IUCN 2006).

Wild boar *Sus scrofa* (Fig. 6) occurs over almost all the ecoregion except the higher zones of the Greater Caucasus (Lukarevsky *et al.* 2004). They are widespread in coniferous, deciduous and mixed forests, scrub and undergrowth in the subalpine zone up to 2600 m (Heptner *et al.* 1961) and occur in the Karadeniz Mountains of NE Turkey (Baskaya & Bilgili 2004). Gutleb (n.d.) reported a recent big increase in wild boar in Iran. The population in Georgia in the mid-1990s was estimated at 8,000 (NACRES 1996). No other regional population estimates are available. Wild boar was globally red listed in 1996 as Lower Risk/least concern (IUCN 2006).

Fig. 4. West Caucasian tur in Kavkasky Zapovednik in Russia (Photo V. Lukarevsky).

Goitered gazelle *Gazella subgutturosa*. Now almost completely restricted to the Shirvan steppes of Azerbaijan (Shchadilov & Hadjiev 2001), which lies outside the distribution of the leopard. A few small populations are known in other parts of Azerbaijan. A reintroduction to Vashlovani Reserve (GE), where a leopard has been present since 2003, is currently planned (Z. Gurielidze, pers. comm. 2006). Distribution in Iran scarcely reaches the borders of the ecoregion (Hemami & Groves 2001).

Medium and small mammals. Indian porcupine *Hystrix indica* is preyed on occasionally in Talysh (Heptner & Sludskij 1972) and southern Armenia (Khorozyan *et al.* 2005). This species also occurs in northern Iran (Harrington 1977) and Vashlovani NP and Chachuna managed reserve (GE). No information is available on its present status in the ecoregion. It was globally red listed as Lower Risk/Least Concern in 1996 (IUCN 2006). European hare *Lepus europaeus* is also widely distributed throughout the ecoregion but details of population density and status are lacking. It was globally red listed in 1996 as Lower Risk/least concern (IUCN 2006). Red fox *Vulpes vulpes* is recorded across the ecoregion.

Fig. 5. Caucasus chamois in Kavkasky Zapovednik in Russia (Photo V. Lukarevsky).

Fig. 6. Wild boar in the Alazani River region (Photo I. Matcharashvili).

Birds

Caucasian snowcock *Tetraogallus caucasicus* occur in the Greater Caucasus on alpine slopes between the treeline and the snowline (del Hoyo *et al.* 1994). Baziev (1978), estimated their numbers at 200,000, based on counts in Kabardin-Balkaria only, where snowcocks are probably more abundant than anywhere else. BirdLife International (2006a) estimated numbers at 100,000-500,000 and red listed it as Least Concern.

Caspian snowcock *T. caspius* are distributed in the Lesser Caucasus, NW Iran and NE Turkey, where they inhabit steep slopes above the treeline (del Hoyo *et al.* 1994). The population in the Caucasus except for NW Iran, is estimated at 5,000–18,000 and the species is red listed as Least Concern (BirdLife International 2006b). However the Caucasus population may be declining faster than in other parts of the range.

Caucasian black grouse *Tetrao mlokosiewiczi* is resident in the Greater and Lesser Caucasus, NE Turkey and NW Iran. Its stronghold is in the Greater Caucasus. Population estimates here range from 15,000–100,000 in RU; 40,000–50,000 in GE; 1,000–1,500 in TR; 110–200 in IR; 150 in AM and 700–3,000 in AZ (BirdLife International 2006c). In total these figures indicate a global – and ecoregional – population of 57,000-155,000. Habitat consists of alpine and subalpine meadows, scrub, and forest edges at 2,000–3,300 m. Habitat loss and deterioration due to livestock grazing and disturbance by shepherds' dogs are believed to be a major threat and illegal hunting is increasing especially in the Lesser Caucasus; it is red listed as Data Deficient (BirdLife International 2006c).

Chukar [rock] partridge *Alectoris chukar* occurs across the ecoregion in open and scrub habitats and pheasant *Phasianus colchicus* is a widespread resident in plains forests and scrub. Neither species is listed as globally threatened.

Livestock

Livestock is widespread across the ecoregion: sheep, goats, cattle, horses, donkeys and poultry, as well as dogs. No region-wide information on numbers is available. There was a significant decrease in livestock in the former USSR after its collapse, but numbers are now growing again, though still lower than before in the North Caucasus. Numbers are rising quickly in Azerbaijan, but slowly in Armenia. There is therefore a big difference between the Armenian and Nakhchyvan slopes of Zangezur Range. Overgrazing in subalpine and alpine pastures has increased by nearly three times (Krever *et al.* 2001). This has clear negative implications for wild mountain ungulates, chukar and Caucasian black grouse. According to Heptner & Sludskij (1972), leopards rarely prey on livestock in places where wild ungulates are abundant, but elsewhere attacks are frequently reported. No systematic survey work is available that allows an assessment of the importance of depredation or the significance of domestic prey for the survival of the leopard.

Discussion

From the foregoing it can be seen that good populations of ungulates survive in some protected areas such as Kavkasky Reserve (RU), Kazbegi Reserve (GE) and Khosrov Reserve (AM), and elsewhere, but all authorities agree that numbers and range of most species have declined over the last 15 years or longer and are becoming fragmented. However, the extent and trajectory of these declines are usually not known in detail. Baseline information is often 20 years old or more, and some figures are at best 'guesstimates' pieced together from fragmentary evidence or brief surveys in limited areas. Accurate population data are lacking for many areas, as are the details of current trends – for example whether the steep declines that began in 1992 have slowed or stabilised. Given the patchy nature of the available information, it is difficult to infer overall trends across the ecoregion.

From the persistence of small nuclei of leopards in a few places in the Caucasus ecoregion one can conclude that the prey base, whatever the composition, is somehow adequate in those places. This is clearly true for Khosrov Reserve, where the population of bezoar goats is described as 'good' by Khorozyan *et al*. (2005) though not enumerated. The leopard living in Vashlovani Reserve (GE) since 2003 is believed by reserve staff to subsist on wild boar, hares and livestock (pers. comm. 2006). However, the extent to which fragmented and depleted prey populations at an ecoregion-wide scale can support viable leopard populations, and over what time scale, is a very important and so far unanswered question. Khorozyan & Malkhasyan (2002) noted that small rodents and hares appeared to be taken by leopards, but only when moving from one rocky habitat patch to another through sparse forest or plateau grasslands. This is an example of the well-known versatility of this species and facilitates dispersal from core populations in Iran, or movement of animals between existing sub-populations. Whether such small prey items could constitute a significant proportion of the diet on a longer-term basis has also not been established; it is generally stated or assumed that medium and large ungulates are necessary. The potential prey spectrum for the

leopard does vary across the ecoregion and further research using scat analysis to clarify dietary preferences in different localities is needed. Mountain ungulates are notoriously difficult to census and the remoteness and inaccessibility of many parts of the Caucasus ecoregion compound the problems in obtaining accurate population estimates. Nevertheless, all efforts should be made to conduct thorough surveys using rigorous methodologies and robust statistical extrapolations and then to instigate monitoring programmes to track population trends in order to provide a sound basis for future conservation planning.

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Mapping the Vision – Potential Living Space for the Leopard in the Caucasus

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The present distribution of leopard (*P. p. saxicolar*) in the Caucasus is restricted to several small nuclei. 100 confirmed leopard observations since 1990 have been used to model the potential distribution of the species in the ecoregion by means of an Ecological Niche Factor Analysis, to assess habitat suitability and patchiness. Variables predicting leopard distribution were terrain ruggedness, distance to highways, and slope, reflecting the inaccessibility of a given area. Best fit was achieved using the harmonic mean algorithm, which produces a rather restrictive model. A total of 123,850 km² were identified as suitable habitat, separated into many patches, of which 12 were >1,000 km². A potential Caucasus meta-population could probably host up to 1,200 leopards. Large continuous clusters are located in NE Turkey, Armenia and west Azerbaijan, and in the eastern part of the Greater Caucasus. Habitat patches in the centre of the Lesser and the west of the Greater Caucasus are smaller and more fragmented. Given the limited input data, the model is relatively coarse, but it allows identifying priority areas for further field surveys and reveals critical areas for the maintenance of habitat corridors for the recolonisation of now empty patches.

The leopard (*P. p. saxicolor*) has lost most of its historic range in the Caucasus ecoregion. Some individuals are still living in the eastern part of the Greater Caucasus, and several population nuclei are known to persist in the Lesser Caucasus, in the south of Armenia and in Azerbaijan (Lukarevsky *et al*. 2007a). Even though these nuclei are likely connected to leopard occurrences in northern Iran, the leopard in the Caucasus must be considered Critically Endangered according to IUCN Red List criteria. To prevent its eradication, first priority is the conservation of the remaining nuclei; but the known distribution area is so small and fragmented that this alone will not be enough to preserve the leopard in the Caucasus in the long term. For a viable population to recover, the known distribution areas must expand and merge, allowing a considerable increase in population size. Top predator populations – and especially solitarily living large cats – need large areas. Protected areas might form strongholds for the persistence of the leopard in the Caucasus, but the big cat will also have to share its living space with people and their demands in a multi-use landscape. As a consequence of natural and anthropogenic fragmentation, the leopard distribution will be irregular, most likely in the form of a meta-population, with several clusters of leopard presence and a limited exchange of individuals between these sub-populations.

At this stage of the strategic planning for the leopard conservation, developing a spatial concept in terms of a meta-population approach is difficult. Nevertheless, it is important to "visualize the vision" at an early stage of the planning in order to recognise the difficulties and opportunities and to agree on certain priorities. In this paper, we use habitat modelling to plot the potential distribution of leopards in the Caucasus. The basic assumption of our approach is that the remnant known leopard nuclei persist within suitable habitats, and that other areas in the Caucasus with similar habitat features would hence also offer potential living space for the species. Extrapolating the character and quality of the known suitable habitat over the whole Caucasus consequently allows discovering other potential leopard habitats. With this modelling exercise, we try to answer the following questions:

1. What is the extent and distribution of suitable leopard habitat within the Caucasus eco-region?
2. How strong is the fragmentation of the potential habitat and what is the size of the identified habitat patches?
3. What is the potential of these patches to host sub-populations and how far are neighbouring extant or potential nuclei?
4. What share of the potential leopard habitat is within protected areas, and where are obvious gaps in the network of the protected areas in regard to the recovery of the Caucasus leopard population?

Methods

Habitat model. The Ecological Niche Factor Analysis (ENFA), developed by Perrin (1984), Hausser (1995) and Hirzel *et al*. (2002), uses presence data only, what is appropriate in situations where absence data are difficult or impossible to collect. The ecogeographical predictors are first summarised into a few uncorrelated and standardised factors – a procedure similar to the Principal Component Analysis. The first factor ex-

plains all the marginality of the species, i.e. how it differs from the average conditions of the study area. The other factors explain the species' specialisation, i.e. how selective it is by comparison to the available range of environmental conditions. The factors were retained as long as their eigenvalue is higher than predicted by a Mac-Arthur's Broken-Stick distribution. A few factors usually explain the major part of the information. Moreover, the amount of information explained by each factor weights the environmental space dimensions in the habitat suitability algorithms. Their small number and independence make them easier to use than the original variables. From this process it follows that the ecological niche factors are relative to the reference area. The mathematical demonstration of this procedure has been developed by Hirzel *et al*. (2002). The species distribution according to these factors is used to compute a habitat suitability index ($0 \leq HS \leq 100$) for any set of descriptor values. Four algorithms (median, harmonic mean, geometric mean, and minimum distance) were used to compute the habitat suitability index (see Hirzel & Arlettaz 2003 for details). The ENFA analyses have been performed with Biomapper 3.2 (Hirzel *et al*. 2006).

Environmental predictors. The Caucasus ecoregion was chosen as reference area, and modelled as a raster map based on Lambert Equal-Area Azimuthal projection (central meridian 44.5 degree; reference latitude 42.6 degree), comprising 602,125 squares of 1×1 kilometre. The land use data, rivers, roads, settlements and protected areas were digitized from 1: 500,000 maps. Elevation came from the SRTM elevation model, a 90×90 m grid. All databases were in digital form and ready to be used in the GIS ArcView (Environmental System Research Institute) and IDRISI 2.0 (Eastman 1997).

From this information, we computed a summary statistics to each 5×5 kilometre cell (e.g. median female leopard home range; see Marker & Dickman 2005): (1) the frequency in the case of the different land use predictors; (2) the standard deviation of the slope as measure of terrain ruggedness, and (3) the mean value in the case of elevation, slope, distances to rivers, dry rivers, channels, highways, main roads, and cities. The environmental predictors have been normalized using the Box-Cox transformation (Box & Cox 1964) prior to the analyses.

Leopard data and potential distribution. Leopard observations available for the Caucasus ecoregion were taken from Lukarevsky *et al*. (2007), comprising a total of 100 chance observations collected since 1990. The function-calculate density from the program ArcView was used to determine the inhabited area based on the available 100 locations. We used the kernel method (Sliverman 1986) to estimate the non-parametric density for the two-dimensional (x, y) data. The search radius was fixed to 15 km and the resolution of the map to 5×5 km. The area of the density grid was progressively enlarged by changing the threshold so that at the end, we got all leopard chance observations included within the boundary of the inhabited area. This happened when all cells >0.002 were included in the distribution area. A binary map of inhabited area (9,250 km²) with multiple centres of activity was obtained. We divided the 370 5×5 -km cells into cross-validation groups following a k-fold partitioning design. Huberty's rule of thumb was used to determine the model training to testing ratio:

$$t = \frac{1}{1+\sqrt{(p-1)}}$$

where t and p are the proportion for test data and the number of environmental predictors, respectively. Based on this rule, a testing ratio of 21% was determined and a k-fold partition of five groups considered. Using cross-validation procedures, we trained our model iteratively on four of the five data sets using ENFA analyses. Validation was based on the remaining testing set. A new evaluator based on a moving window of width W instead of fixed classes was computed. This provides a smooth predicted by expected ratio of evaluation points on which a continuous Boyce index can be computed (see Hirzel *et al*. 2006 for details).

The cut-off value of the habitat suitability map was fixed arbitrary in a way that 80% of the cells of the inhabited area were included in the boundaries of the potential distribution map. Patches were defined using the tool RegionGroup of the program ArcView (ESRI 1996a, b, c). Each 5×5 km grid cell was grouped into a connected region assigning a unique number to each region in the GIS. Cells that were orthogonal or diagonal to each other were considered to be connected.

Table 1. Sixteen predictors retained in the habitat suitability and result of the ENFA analyses. The response variable is the area occupied by leopard based on the Kernel analysis. The 5x5 cells of the inhabited area (n =370) were used to generate and validate the models. EP = Environmental predictor, factors: *M* = *Marginality*, *S1*, *S2*, *S3* and *S4* = *Specialization*. Bold = EP with an absolute score ≥ 0.2. The scores of the marginality are sorted in a decreasing order. Variable category: Top = topographical; Bio = biological; Ant = anthropogenic.

EP	Cat	***M***	***S1***	***S2***	***S3***	***S4***
Slope [SD]	Top	**+0.416**	**0.393**	**0.312**	**0.623**	**0.600**
Distance to highways [mean]	Ant	**+0.412**	**0.277**	**0.24**	0.02	**0.204**
Slope [mean]	Top	**+0.403**	0.149	**0.349**	**0.623**	**0.698**
Elevation [mean]	Top	**+0.355**	**0.518**	**0.745**	0.078	0.166
Summer pastures [freq]	Bio	**+0.347**	0.009	0.199	0.112	0.013
Distance to channels [mean]	Ant	**+0.235**	**0.582**	0.188	0.150	0.015
Rocks [freq]	Bio	+0.142	0.068	0.01	0.027	0.008
Distance to main roads [mean]	Ant	+0.139	0.05	0.162	0.158	0.007
Forest [freq]	Bio	+0.092	0.008	0.135	0.014	0.033
Pastures around villages [freq]	Bio	+0.087	**0.213**	0.000	0.181	0.076
Distance to cities [mean]	Ant	+0.075	0.108	0.032	0.044	0.051
Winter pastures [freq]	Bio	+0.069	0.003	0.055	0.046	0.033
Distance to dry river [mean]	Bio	-0.029	**0.259**	0.068	**0.332**	0.017
Villages [freq]	Ant	-0.086	0.016	0.050	0.085	0.009
Distance to rivers [mean]	Bio	**-0.228**	0.075	0.002	0.043	0.140
Intensive agriculture [freq]	Ant	**-0.260**	0.058	0.194	0.010	**0.231**

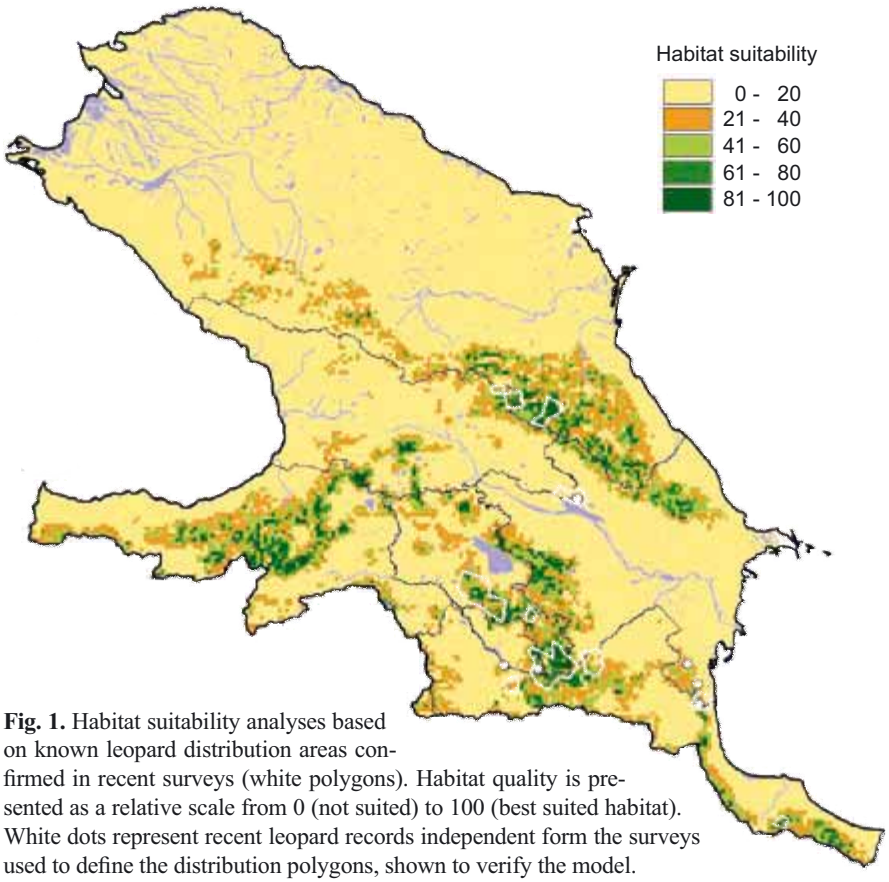

Fig. 1. Habitat suitability analyses based on known leopard distribution areas confirmed in recent surveys (white polygons). Habitat quality is presented as a relative scale from 0 (not suited) to 100 (best suited habitat). White dots represent recent leopard records independent form the surveys used to define the distribution polygons, shown to verify the model.

Results

By applying the ENFA method to the calibration sets, we got an overall marginality *M* of 1.139 and an overall specialization value *S* of 1.576, indicating that leopard's habitat differs from the average condition in the Caucasus ecoregion. According to the Mac-Arthur's Broken-Stick rule, five factors (*M*, *S1–4*; Table 1) were retained, accounting for 86% of the total specialization. The *marginality* factor alone accounted for 100% of the *marginality* and for 30% of the total *specialization* and showed that leopard observations were essentially linked to terrain ruggedness (slope SD), slope, distance to highways, elevation, distance to channel, and summer pastures frequency (Table 1). On the other end, leopards tended to avoid areas far from rivers as well as intensive agricultural areas. The second (15.3% of the total *specialization* explained), the third (10.8%), the fourth (8.7%), and the fifth (6.2%) factor accounted for more *specialization*, mostly regarding terrain ruggedness, elevation, slope, and distance to highways and channels, respectively. The habitat suitability map (Fig. 1) was computed using the species distribution on these factors. The validation revealed that prediction performance were best accounted by the harmonic mean model with a continuous Boyce index ($B_{cont(0.1)} \pm SD$) of 0.817 ± 0.1013, compared to the other algorithms (geometric mean: 0.686 ± 0.1087, minimum distance: 0.678 ± 0.2059 and median: 0.461 ± 0.2433).

The cut-off value of the habitat suitability map was fixed arbitrarily in a way that 80% of the presence cells were included in the boundaries of the potential distribution map (Fig. 2). When ignoring all patches <1000 km², the model divided the leopard habitat into 12 suitable patches. 3 patches (number 10, 11 and 12; Fig. 3, Table 2) were >20,000 km², with the largest being 33,550 km². In some patches (e. g. patch no. 12, Zangezur-Talysh in the south-eastern part of the ecoregion), large clusters of suitable habitat were connected only through small bands of habitats, which have more the character of a corridor and may act as bottlenecks for the movements of leopards within the patch.

The total area of suitable habitat in the Caucasus is about 123,850 km² (Table 2), of which less than 13 % are within protected areas (Fig. 2). On the other hand, more than 60 % of the protected area is no leopard habitat, mainly of course the wetland reserves. The largest continuous protected area, formed by several adjacent PAs in Chechnya, Dagestan and the triangle RU, GE and AZ (Fig. 2) is about 3,050 km² of suitable habitat. Assuming a moderate leopard density of 1 resident individual/100 km² suitable habitat (see discussion), the Caucasus could host a meta-population of about 1,200 resident leopards.

Table 2. Patches of suitable leopard habitat in the Caucasus. Patch number refers to Fig. 3. The area represents the number of 5×5 km grid cells in each patch and the sum of the residual patches <1000 km². Adjacent patches are those separated not more than 1 or, if patch number in bracket, 2 grid cells apart.

Patch no.	Region	Countries	Area (km²)	Adjacent to patches
1	Ardahan	TR, GE, AM	1,000	7, 10
2	Ossetia	RU, GE	1,175	8,11
3	Kars-Igdir	TR	1,375	-
4	Dilijan	AM	1,450	(7)
5	Qotur	IR, TR	2,525	-
6	Giresun	TR	2,950	-
7	Trialetis-Bazumi	GE, AM	4,000	1, 10, (4)
8	Cherkessia	RU	4,275	2
9	Gilan-Elborz	IR	4,425	(12)
10	Erzurum	TR, GE	22,425	1, 7
11	Dagestan	RU, AZ, GE	32,675	2
12	Zangezur-Talysh	AM, AZ, IR	33,250	(9)
Residual	-	-	12,325	-
Total			123,850	

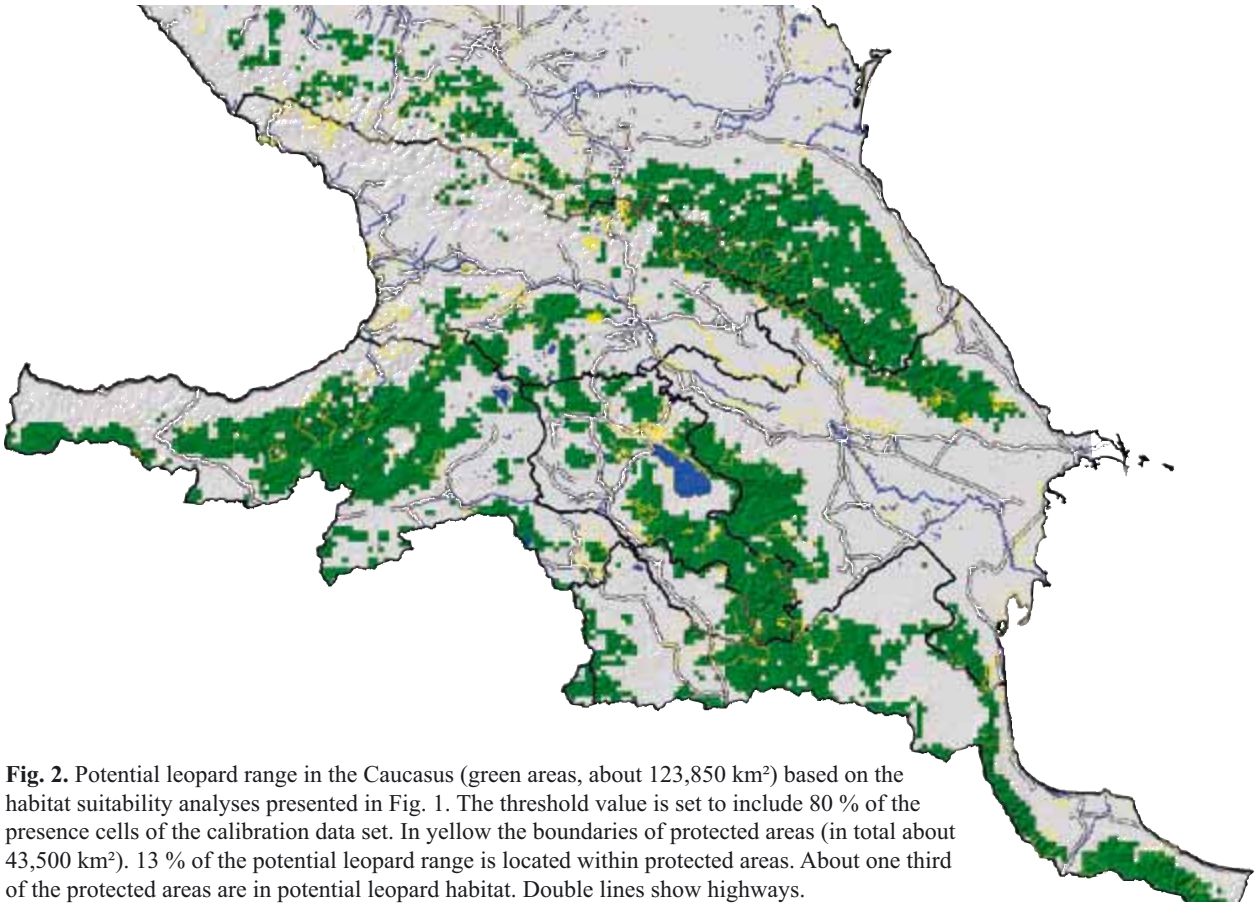

Fig. 2. Potential leopard range in the Caucasus (green areas, about 123,850 km²) based on the habitat suitability analyses presented in Fig. 1. The threshold value is set to include 80 % of the presence cells of the calibration data set. In yellow the boundaries of protected areas (in total about 43,500 km²). 13 % of the potential leopard range is located within protected areas. About one third of the protected areas are in potential leopard habitat. Double lines show highways.

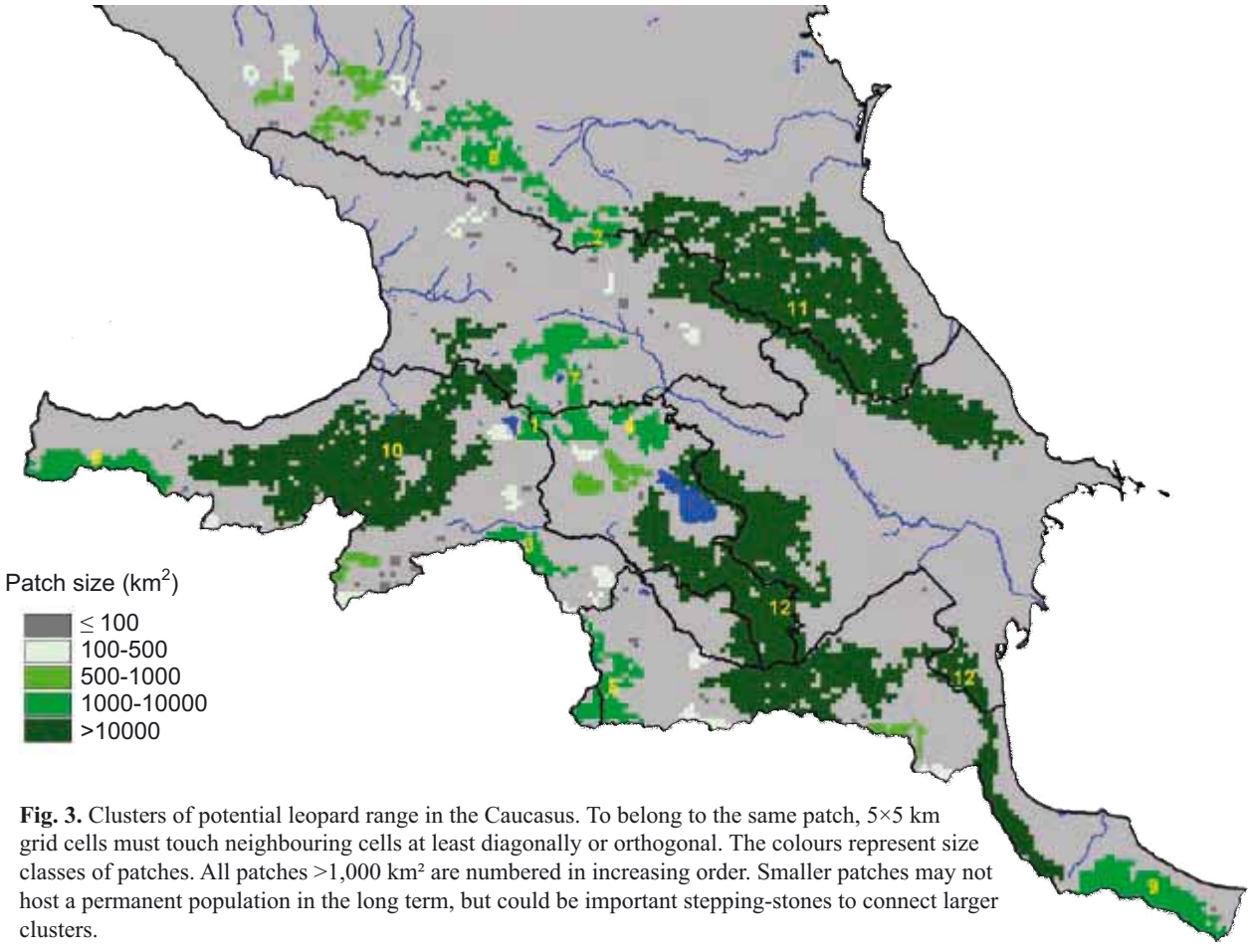

Fig. 3. Clusters of potential leopard range in the Caucasus. To belong to the same patch, 5×5 km grid cells must touch neighbouring cells at least diagonally or orthogonal. The colours represent size classes of patches. All patches >1,000 km² are numbered in increasing order. Smaller patches may not host a permanent population in the long term, but could be important stepping-stones to connect larger clusters.

Discussion

Our model predicts a total extension of suitable leopard habitat in the Caucasus eco-region of 123,850 km², of which about 110,000 km² form twelve clusters of >1000 km² rather continuous habitat (Table 2). Only patch no. 12, bridging the known leopard nuclei in the centre of the Lesser Caucasus with the Talysh Mountains, is not a very coherent cluster. But this patch and especially its corridor across the Qarah Su valley in northern Iran is essential, as it potentially connects the Caucasus occurrences with the leopard populations in the Elburs (Alborz) and even the Kopetdag ranges further east. In regard to the recolonisation of the Caucasus and the long-term (genetic) preservation of the population, the maintenance of corridors is of high importance[1]. Even the coarse resolution of our present model makes obvious where the critical connections between neighbouring clusters are, and where it will be important to maintain the connectivity and, where needed, restore the ecological features of existing or potential corridors. A habitat model furthermore allows testing for the potential effect of future infrastructure development, such as the construction of new highways or water reservoirs on the potential leopard distribution area.

Another 12,325 km² suitable habitat are distributed over the whole Caucasus in numerous clusters <1000 km², as small single isolated 5×5 km grid cells. The high fragmentation of the habitat is especially obvious in the western part of the Greater Caucasus (Fig. 2, Fig. 3). These small patches are too small to host a population, but they might be important stepping-stones between larger clusters, hence support the connection between potential sub-populations. The basic assumption of habitat modelling is that the known present distribution areas are in the best-suited habitats. A species may however not only exist in one type of environment (unimodal distribution of factors), but in several (multimodal). The algorithms – median, minimum distance, geometric mean, and harmonic mean – have to be chosen according to the distribution. However, the distribution of factors is often not known, especially if the remnant distribution area or the input data are limited. Then, the algorithm of best fit should be used, in our case the harmonic mean. This algorithm increase the influence of the observations close to the distribution centre (Hirzel & Arlettaz 2003) and produces rather restrictive distribution maps compared to other algorithms. It nevertheless "discovered" well-suited habitat quite far from known areas of presence, e.g. in NE Turkey. The fact that the north-western part of the Caucasus (Fig. 4), which has a high cover of forest, is in relatively low suitability classes may be a consequence of the large geographic (and hence ecological) distance to the origin of the leopard input data, but may as well express real constraints: This region was also in historic times the edge of the leopards distribution range and was lost relatively early, and none of the field transects performed in this region produced positive results (Lukarevsky *et al*. 2007a).

A few recent leopard records (which were not used to compute the model) are available to "test" the model. They are all located within or close to the higher habitat suitability classes (white dots in Fig. 1), with the exception of the one from Ilisu Branch NR. This NR is however very small and clearly isolated from the large habitat clusters in the Greater and the Lesser Caucasus. It might be important as a "stepping stone" in a corridor, but will never host an independent population. The habitat model is at this stage relatively coarse and hence speculative. On one hand, input data were limited: The leopard data available (Fig. 1) were limited in number and quality (all survey data – see Lukarevsky *et al*. 2007a – have an "anthropogenic bias", as they always depend on the presence of the researcher) and some of the space and landscape features used to develop the model (Table 1) over the whole Caucasus were only available in a limited resolution. Model building is a deductive-inductive process, with model formulation and validation occurring iteratively. Once additional leopard data from other areas or gained with independent methods (e.g. radio-telemetry) are available, new validations should be performed. With more leopard data available, the model should be computed again, with data split into several subsets according to observation categories (e.g. direct observations versus track transects and versus radio-tracking data) to test for possible biases and to assess their ability to predict leopard distribution.

On the other hand, the model does not consider prey availability. There are both practical and conceptual reasons refraining from including prey data: (1) Prey information is not consistently available over the whole range (Mallon *et al*. 2007), (2) "suitable leopard habitat" incorporates the suitability of a given landscape for leopard prey, as generally, the prey is more habitat dependent than the predator (and consequently, including a prey layer would result in a pseudo-replication), and (3) prey may have recently decreased as a consequence of over-hunting, but the anthropogenic influence differs between areas (Lukarevsky 2004, Lukarevsky *et al*. 2007a, Mallon *et al*. 2007, Williams *et al*. 2006). The model describes where the landscape according to its geographic, topographic and habitat features would be suited to host leopards; it does not predict whether shortage of (wild) prey or conflicts with local people would limit the presence of the big cats. These are factors, which must, like any other threat, be assessed and mitigated where needed prior to a possible recovery of the leopard. Such detailed information is not yet or only for limited areas available for the leopard. The model also allows identifying gaps of knowledge and information. If we compare the distribution of negative and positive field surveys (Fig. 3 in Lukarevsky *et al*. 2007a) with the map of potential leopard habitat (Fig. 2), it is obvious that not all potential areas have been surveyed yet. The most obvious gaps are in the eastern part of the Greater Caucasus (Russia and Azerbaijan), and in the Lesser Caucasus north-east Turkey and western Azerbaijan.

Of the more than 120,000 km² suitable habitat identified by our model, only about 9,250 km² are presently known to be settled by leopards (Fig. 1). According to the estimation by Lukarevsky *et al*. (2004, 2007a), not more than 15 and

[1] In this respect, the status of the leopard population and the fragmentation of its distribution range in northern Iran are of outstanding importance for the future of the leopard in the Caucasus, and a comprehensive survey of the areas south of the Caucasus ecoregion would strongly support the conservation planning for the leopard.

50 leopards live today in the Greater and Lesser Caucasus, respectively. But what is the potential of the Caucasus to host a viable leopard population – assuming that a successful recovery in all suitable habitat would be successful? Density indications available for the leopard in the Caucasus are very crude guesses. Khorozyan (2003) indicated a density of 0.4 leopard/100 km² from track transects in Armenia (see explanations in Lukarevsky *et al*. 2007b). Lukarevsky (2004) estimated the number of leopards in some protected areas of known size in northern Iran: The Arasbaran Biosphere Reserve (725 km²) hosts 5–6 leopards on 500 km² suitable habitat; the Kiamaki Reserve 8–9 leopards on 844 km². This points to a possible density of about 1 leopard/100 km². Lukarevsky *et al*. (2004) believed that under good conditions, groups of 5–10 leopards could live on areas of 150–300 km², hence on a density of 3.3 leopards/100 km². With a low to moderate density of 0.5–1 leopard/100 km², the potential total population would be some 600–1200 leopards (of which about one third in the Greater and two thirds in the Lesser Caucasus), hence a population size that we can consider "viable" even under genetic considerations. But this is rather speculative. There is no doubt that leopard densities vary considerably with prey availability and other ecological factors (Marker & Dickman 2005), but the wide range of estimations for the Caucasus based on the presently available information and expert opinions demonstrates that we definitely need more reliable data on the land tenure system of leopards in the Caucasus to assess the size of potential local occurrences. However, considering that the lower density estimation of 0.5 leopard/100 km² is a conservative assumption and that the main clusters are relatively large and well-connected through smaller patches of suitable habitat, the model demonstrates that it might be visionary, but by no means illusionary to plan the recovery of a viable meta-population of leopard in the Caucasus.

Fig. 4. Kavkasky Zapovetnik (RU). The northwest Caucasus was, together with the Primorski-Kraij in the Russian Far East, the northern edge of the global *Panthera pardus* distribution and the only area where leopards were living in mainly coniferous forests. The local occurrence was eradicated decades ago, but the region is now target for a reintroduction project (Photo WWF, F. Mörschel).

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General Conditions for the Conservation of the Leopard in the Caucasus

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For the conservation of the leopard, a highly endangered flagship species of the Caucasus ecosystem, a close cooperation between governmental agencies, non-governmental organisations and scientists on national and international level is needed. The programme implies not only protection of the leopard, but also preserving its habitat and wild prey, and working with various stakeholders from the international level down to local people. Such a complex programme requires well-designed communication and planning. The first step is to compile all available information in a status report to assess the present situation. Then, a range-wide conservation strategy needs to be developed in a participatory process involving all relevant organisations from the range states and international partners. This strategy defines the common goals and provides a framework for the planning of conservation activities in each country. The third step will be the development of national action plans, allowing the involvement of stakeholders and local people and the assignment of concrete tasks to the designated actors.

Panthera pardus saxicolor, the North Persian leopard, is listed as Endangered in the IUCN Red List of Threatened Species (www.redlist.org). Considering the low numbers and fragmented distribution of the species in the Caucasus (Lukarevsky *et al.* 2007a), a regional assessment must conclude that within this eco-region, the species is even Critically Endangered. The six countries sharing the Caucasus range – Russia, Georgia, Armenia, Azerbaijan, Turkey, and Iran – have red-listed the species and/or established protected areas in the leopard habitats (Lukarevsky *et al.* 2007a; Zazanashvili *et al*. 2007). The leopard is the number one focal species in the Ecoregional Conservation Plan for the Caucasus (Williams *et al*. 2006) and considerable efforts for its conservation have been undertaken in recent years (summarised by Zazanashvili *et al*. 2007). According to Lukarevsky *et al*. (2007a), the newest data (or rather the lack of data) indicate a further decline of the population in the most recent years, after some positive signs in the first years of the century. We believe that the information is too inconsistent for such a judgment and that more rigorous monitoring data are urgently needed. But regardless to annual fluctuations in records, the situation of the leopard in the Caucasus is alarming, and more efforts and new initiatives are needed.

The conservation of the leopard in the Caucasus is a particular challenge. The need for huge space for a viable population entails a close cooperation across national and international borders, which is however impeded by the economic and political problems in the range countries. On the other hand, conserving the region's natural heritage offers the opportunity to work together towards a common goal that is widely accepted across all borders and cultures. But a solemn promise alone will not save the leopard. What we need is (1) a clearly structured cooperation between all partners involved, (2) the implementation of well-planned actions, and (3) a monitoring system that allows assessing and where needed correcting the measures taken.

In this paper, we describe the larger context of leopard conservation in the Caucasus and outline the planning process. Realms to be considered (Fig. 1) are: (1) population interventions (species or population level), (2) securing important places (landscape and habitat level), (3) analysis and reduction of threats, and (4) providing enabling conditions. All these aspects influence – positively or negatively – the conservation of the leopard in the Caucasus and must be considered in a comprehensive conservation strategy. The preservation of a large carnivore on a regional level is a complex endeavour, and it is impossible to assess and to discuss all factors in this chapter. The intention of this work is to provide a conceptual framework for the conservation of the leopard in the Caucasus and to facilitate the development of a conservation strategy at the strategic planning workshop in Tbilisi, Georgia form 30 May to 1 June 2007.

Underlying factors

Conservation planning must not only consider ecological conditions, but also underlying factors such as cultural, geopolitical, socio-economic and institutional aspects and foresee future developments, constraints, and opportunities. Two excellent documents – the United Nation Environmental Programme's *Caucasus Environmental Outlook 2002* (CEO; www.grid.unep.ch) and the *Ecoregional Conservation Plan for the Caucasus* (Williams *et al*. 2006) compile these factors and provided valuable background information.

Socio-economic aspects. The political and economic situation of the range countries is a key factor in leopard conservation. The economic breakdown after the disintegration of the Soviet Union led to an increase in exploitation of natural resources through woodcutting, overgrazing, unregulated hunting of animals and collection of plants (Krever *et al*. 2001; Zazanashvili *et al*. 2007). Commercial logging, once an important branch of local industry, dropped significantly, but the energy crisis caused an increase in unregulated woodcutting to obtain firewood, leading to degradation of forests (see below).

Poverty of rural people is – and will be for years to come – a serious impediment for the conservation of natural resources and the natural heritage. One third to half of the 35 million people in the Caucasus live below the poverty level. For these people, the conservation of the leopard that threatens their livestock and competes for game is probably no priority. Many people in villages (Fig. 2) must supplement their incomes with food from vegetable gardens, livestock, fishing, and (illegal) hunting. However, the human population living in remote areas is decreasing. Half of the human population lives nowadays in urban centres, and the rural exodus continues. Migration and falling birth rates have caused the human population to drop by 7–10 percent since 1990, and it is further declining in Armenia and Georgia.

Human dimension and cultural aspects. Information on human attitude and conflicts between local people and leopards in the Caucasus region is very limited. In Armenia, 80 people have been interviewed in rural areas (Khorozyan 2001). All interviewed people said that leopards never visit agricultural lands or villages. Only one case of depredation was captured in the inquiry; most people were not aware of livestock or pets being killed by leopards. The individual attitude of people towards leopards was indifferent. Human attitudes may differ between countries or cultural regions, but such information is not available or has never been compiled.

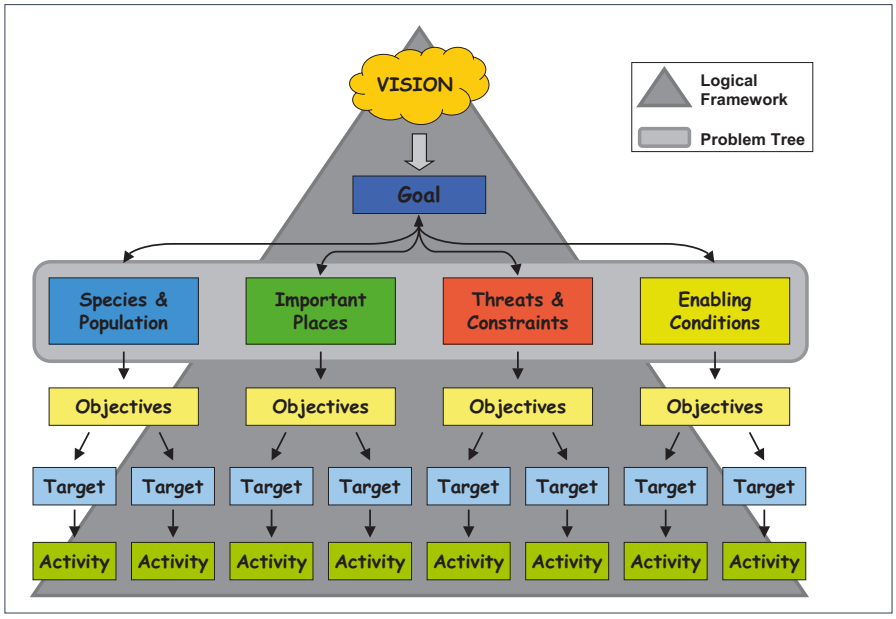

Fig. 1. Logical framework pyramid for the development of a conservation strategy. Vision and Goal define the long-term aims, Species & Population, Important Places, Threats & Constraints and Enabling Conditions define the levels of intervention (see text). Objectives, Targets and Activities describe the steps for the implementation of conservation measures.

Population considerations

Species persist in a given area neither as systematic entity nor as individuals, but as populations. The long-term goal of our efforts must be to restore a viable population and – beyond a "minimum viable population" – to maintain the leopard as an integral part of the Caucasian eco-system. The taxonomic uniformity of the leopard in the Caucasus is not definitely agreed (see Lukarevsky *et al*. 2007b), but we consider the whole Caucasus to belong to the historic range of the same subspecies. The present number and distribution of leopards is so limited (Lukarevsky *et al*. 2007a) that securing the present status will not be sufficient to save the population. Nobody can exactly predict what size a "viable population" must have, but we should aim for a magnitude of several

Fig. 2. Mountain village in Azerbaijan. People in the mountains who struggle for day-to-day survival consider the leopard as a competitor and may see its conservation not as a priority (Photo WWF, F. Mörschel).

hundred individuals to maintain a demographic and genetic healthy population. It goes without saying that the preservation of the remnant occurrence is first priority, but then, the extant nuclei need to recover and lost ground be regained. Considering the fragmented distribution of suitable habitats (Zimmermann *et al*. 2007), the leopard will survive in the Caucasus as a meta-population, with several relatively closed sub-populations, which are separated from each other, but connected through corridors (see below) allowing the migration of dispersing individuals. Some of the occupied areas may serve as "sources" – well-protected sites producing a surplus of leopards – whereas other areas or sub-population may be "sinks", depending on immigrating animals because the local reproduction cannot compensate for the mortality. The possible shape of a future meta-population – size and source or sink status of each sub-population and its connection to neighbouring sub-populations – is important to consider in conservation management planning. Compared to other large mammals, cats are relatively bad colonisers, and most likely, active translocations or reintroductions may be needed to recover the Caucasus leopard population. Parameters describing a population are the land tenure system (social set-up and individual space use), habitat use, recruitment, dispersal and mortality. This information is still lacking for the leopard in the Caucasus. As additional data become available, refined spatially explicit models (see Zimmermann *et al*. 2007) will allow improved planning of the meta-population approach.

Securing important places

Conservation of large carnivore populations takes place at landscape level. Assuming a potential average density of 1 leopard/100 km², a population of 500 individuals would cover an area of 50,000 km². All known existant occurrences are located within protected areas (Lukarevsky *et al*. 2007a; Zimmermann *et al*. 2007). If well protected, the larger of the protected areas can serve as sources, allowing the leopard to expand into neighbouring sites. Within protected areas, protection of habitats, prey, and leopards must have clear priority over any other use, and this protection must be enforced. Our knowledge on the present status of the leopard is sufficient to identify the key protected areas: PAs with known leopard presence, those acting as stepping-stones towards the adjacent leopard populations in the south and southeast, and the priority sites for being re-colonised in the near future. But the leopard population will also need to expand over non-protected suitable areas. Such human dominated multi-use landscapes may be a sink for the leopard, but they are nevertheless important for the thriving of the entire population. Management schemes – e.g. compensation of livestock losses or removal of problem leopards – may here differ from protected areas, in order to gain the support of local people for leopard conservation. Between the sub-populations, across the landscapes not suited for the permanent presence of leopards, corridors will grant the exchange of individuals maintaining the genetic integrity of the meta-population. Corridors are stripes of habitat allowing the temporary use, but not the permanent presence of resident leopards. Dispersing subadult individuals can use corridors to leave their natal range and gain new living space. To identify and maintain corridors is crucial for the recovery and maintenance of a meta-population.

Fig. 3. A Leopard (left) and a lynx (right) skin hanging in front of a house in southern Armenia. Poaching is believed to be a major threat to the survival of the leopard in the Caucasus (Photo V. Lukarevsky).

Threat reduction

To halt the further decline and prepare the recovery, factors threatening the leopards must be mitigated. Information allowing an assessment of the significance of the various threats in the Caucasus is very limited. But there is little doubt that the decline of the leopard in the ecoregion is a variation on a common theme: direct persecution (poaching and retaliation killing), indirect threats (habitat destruction and prey depletion) and possibly intrinsic factors (disease, demographic and genetic problems). These categories of threats go normally hand in hand and accelerate the vortex of extinction when the population is increasingly under stress (see Breitenmoser 1998).

Direct persecution. Illegal killing occurs in all range countries. Since 1990, we know about 23 leopards, which were killed or removed in 19 events (AM, 11; AZ, 6; GE, 1; RU, 5; Lukarevsky *et al*. 2004, Khorozyan 2000; E. Askerov and V. Lukarevsky, pers. comm.). In Azerbaijan, according to interviews with villager from Ordubad and the mountains

of Gazangeldag, at least two leopards were killed and one was injured when it attempted to attack cattle in the early 2000s. Attacks on domestic animals are one of the reasons of hostility and the conflict between people and the leopard in south Nakhchyvan (Lukarevsky *et al*. 2004). Conflicts over livestock seem to be the root cause for illegal killing, but no data are available to assess the amount of the depredation or retaliation killing. It is also impossible to estimate the number of unreported cases and hence to assess the impact of illegal killing on the population level or to compare its significance with other causes of mortality. However, the fact that in Armenia in 2000 alone, four cases of illegal killing were discovered (Fig. 3) indicates that the impact of illegal killing must be considered important. Historic hunting bags for large cats demonstrate that healthy populations normally can stand a considerable loss from direct persecution; but as soon as a population is under pressure from habitat loss or prey reduction, the impact of hunting or poaching escalates.

Fig. 4. Member of an anti-poaching unit (APU) detains a poacher in Armenia (Photo WWF, K. Manvelyan).

Habitat destruction and prey depletion. Large carnivores are – compared to herbivorous species – less habitat dependent, and leopards are among the most adaptable of the cat species. They are, however, indirectly affected by habitat destruction as it strongly influences prey distribution and availability. About a quarter of the Caucasus remains in reasonably natural condition; less than 12 % can be considered pristine (Williams *et al.* 2006). Forest exploitation (logging, grazing) has lead to habitat degradation and fragmentation. In Armenia, 270 km² of forests (8% of the national forest area) were cut down from 1992–95 during the energy crisis.

Forest and habitat decline went along with a decrease of wild and an increase of domestic ungulates. Numbers and range of most prey species have declined over the past 15 years or longer and populations are becoming fragmented (Mallon *et al*. 2007). The extent and trajectory of these declines are usually not known, as population data are lacking for most areas. Poaching and illegal wildlife trade have increased as the result of the economic crisis (Williams *et al*. 2006). Uncontrolled hunting of game is particularly widespread in mountain regions. Quotas for game species are set without monitoring of the populations, and harvest rates are often not sustainable. Overabundant livestock competes with wild ungulates for fodder. Sheep grazing in winter ranges and in steppes and semi-deserts of the eastern Caucasus have nearly tripled over the past decade. Overgrazing and uncontrolled livestock pasturing threaten also subalpine and alpine ecosystems. Today, already a third of the pastureland suffers from erosion (Williams *et al.* 2006) as a consequence of unsustainable livestock husbandry practice.

Fragmentation and infrastructure development. Loss of habitat quality and prey availability may first turn a source area into a sink, and, as deterioration continues, turn it into unsuitable and hence unoccupied space, cutting the original distribution area into pieces. Large clusters of potentially suitable habitat still exist (Zimmermann *et al*. 2007). Fragmentation does not seem to be the main reason for the vanishing of the leopard. It may, however, form a considerable obstacle for its recovery. Along with the economic development, traffic lines, hydropower reservoirs and other potential barriers will increasingly bisect the habitat for wildlife and especially cut through important corridors, which are typically in valleys. Rural exodus reduced the human population in the mountains, but urban areas boosted and construction of infrastructure increased, mostly built without environmental impact assessment. As a consequence of the renaissance of the "Silk Road", TRACECA (Transport Corridor Europe-Caucasus-Asia) – constructed with financial investments from the European Union and other international institutions – transport volumes across the Caucasus increase year by year, and many new roads are being built. Lately, Armenia planned a new road to Iran; 17 of the 90 Armenian kilometres would have cut through Shikahogh Reserve – one of the country's key areas for the leopard. WWF and other local and international organisations helped to find alternative routes and save the reserve (www.panda.org).

Intrinsic factors. Small, isolated populations face an increasing risk being affected by disease, demographic or genetic problems. We lack any information to assess these potential threats to the leopard in the Caucasus. The extremely low number of individuals estimated for some of the remnant nuclei (Lukarevsky *et al*. 2007a) let however fear that many of them are demographically no longer functional.

Enabling conditions

To encounter threats and support conservation actions, a number of enabling conditions must be established:

Institutional and organisational aspects. Cooperation between several countries and different public and private organisations requires regular exchange of information. So far, NGOs have been driving forces in establishing such contacts. The *WWF Caucasus Programme Office* in Tbilisi, Georgia coordinates the regional conservation activities. In 2001, the *Caucasus Biodiversity Council* (CBC) was founded. The council meets twice a year and works on vital conservation problems in the eco-region. Each countriy sends one representative from the Ministry of Environment and one from a civil society organisation. The Council assists and monitors projects and programmes and facilitates cross-border conservation work and has become an important forum for conservation in the region.

Political commitment. In March 2006, KfW Development Bank and WWF Germany organised a conference in Berlin under the auspices of the German Federal Ministry for Economic Cooperation and Development, BMZ. The conference brought together the ministers of environment from the Southern Caucasus countries, as well as representatives of Iran, Russia, Turkey, international conservation and donor organisations. The conference aimed to strengthen the dialogue between governmental and non-governmental organisations in the field of nature conservation and sustainable development, and confirmed the commitment of the Caucasian countries to work together to conserve their mutual natural heritage. Two new and concrete initiatives were agreed: the establishment of a Caucasus Protected Areas Trust Fund (see below under funding) and a Caucasus Monitoring Network. The targeting of the three Caucasus countries of Armenia, Azerbaijan and Georgia for the new European Neighbourhood Policy under the auspices of the European Union has also created a new and important platform for developments, including new finances, review of key legislation and engagement of the civil society, which could be beneficial for the conservation of the entire Caucasus, including the leopard.

Professional capacity. Improved capacity in wildlife conservation and related domains is needed across the Caucasus. Khorozyan (2004) concluded for Armenia that a good start was done strengthening capacity for biodiversity conservation that however more needs to be done; this is true for the entire region. More efficient law enforcement is urgent. Anti-poaching units (APUs) have been established since 2003 in Armenia (Fig. 4). Several capacity building workshops have been organized, and a manual was published with support from WWF/CEPF (see below). In Georgia the NGO Ecovision supported customs officers fighting illegal wildlife trade in Georgia. Training programmes for border guards and rangers of the Hyrcan National Park (AZ) were offered, and Khorozyan (2004) organised similar programmes – including educational material in Russian – for border patrols and border army units in Armenia.

Awareness and education. Public awareness and education activities have been addressing different target groups. WWF organised numerous programmes for school children (Fig. 5) with theatres, art contests, and essays around leopard, and eco-camps for 42 school children and five teachers in Armenia and Azerbaijan. The broad public was informed about leopard conservation through articles in newspapers and TV shows. Posters and booklets were distributed to local rural communities, national authorities, border militaries, and soldiers (Khorozyan 2004).

Funding. Governmental funding for conservation is still scarce in the Caucasus ecoregion, but as the region is a priority area for economic development and a designated Hotspot for the conservation of biological diversity (Mittermeier *et al*. 1999), international funding is available also for conservation projects. WWF, Conservation International (CI) and the German Ministry of Economic Development and Cooperation (BMZ) with support of the German Development Bank KfW established a trust fund providing long-term financial sustainability for priority protected areas in Armenia, Azerbaijan and Georgia with a start-up funding of nine million US$ in 2006. Together with GEF, the World Bank, the MacArthur Foundation and the Japan Government, CI created the Critical Ecosystem Partnership Fund (CEPF). In the Caucasus Hotspot, CEPF has four main funding priorities: (1) to support civil society efforts that promote transboundary cooperation and improve protected area systems in five target corridors; (2) to strengthen mechanisms to conserve biodiversity in the Caucasus Hotspot with emphasis on species, site and corridor outcomes; (3) to implement models demonstrating sustainable resource use in five target corridors; and (4) to increase the awareness and commitment of decision-makers to biodiversity conservation in five corridors. More specific for leopard, WWF has funded a first phase of the Caucasus leopard project (2001–05). This project has initiated research and surveys (Luvarevsky *et al*. 2007a). Financial support has come from WWF Switzerland, and since 2003 also from WWF Germany (Zazanashvili *et al*. 2007). Leopard conservation work in Armenia was furthermore supported by The Whitley Awards (Khorozyan 2004) and by the People's Trust for Endangered Species (D. Mallon pers. com.).

Planning process and implementation of conservation actions

The planning process is a conservation activity on its own, as it is the starting point for building partnership and involvement of stakeholders. In a large, culturally and politically diverse region such as the Caucasus, the planning must be stratified and decentralised, as it is impossible to gather all groups concerned in one place. Yet, range-wide considerations – e.g. defining objectives at the meta-population level – exceed the local scope and must be agreed upon between the national institutions involved. We therefore recommend a planning process on two levels: (1) development of a regional conservation strategy setting general goals for the entire eco-region and defining the cooperation at international level, and (2) the establishment of national or sub-regional action plans

defining the concrete measures and actions as implementing tools of the conservation strategy.

Partnership and stakeholder involvement is needed both on regional and local level. Partners for the development of the range-wide strategy are national governmental agencies in charge of nature conservation and wildlife management, non-governmental nature protection organisations, and scientific experts (the "Triangle of Conservation"; Breitenmoser *et al*. 2006). These institutions must work together in the strategic planning (agree on principles and priorities for the recovery of the metapopulation), and organise and supervise the implementation of the strategy on national and sub-regional level. On the second level, where national or sub-regional action plans are being developed, the partnership includes institutions responsible for agriculture and forestry, economy, civil engineering, energy, and education, and the involvement of local people. Experience proves that a species such as the leopard cannot simply be "protected". Even if the law protects the species and part of its range, other, higher ranked interests and priorities may compromise the legal protection. A consensus is needed between the conservation community, other stakeholders, and the local people directly affected by conservation measures. Such consensus can often be achieved through integrating all groups concerned already into the planning phase.

Development of conservation plans. The first step towards a comprehensive conservation action plan is an assessment of the situation to provide baseline information for the planning process. This is a task for scientists and professional services.

Then, a conservation strategy is to be developed as a master plan for the conservation of the leopard across the Caucasus ecoregion. The strategy must include the identification of long-term goals and conservation measures on the range-wide level and define the cross-border cooperation. The Conservation Strategy for the Leopard in the Caucasus is to be endorsed by the range country governments, so that it can provide political and conceptual guidance and set the standards for the following action planning on national or sub-regional level. This third step – the development of action plans – translates the principles of the conservation strategy into concrete measures and activities to be implemented in the field. The action plans assign tasks for specific areas to certain institutions and define a schedule for their execution. The conservation strategy and the national or sub-regional action plans are developed in a participatory process using e.g. a logistic framework approach (Fig.1; Breitenmoser *et al*. 2006), allowing the critical buy-in and integration of different knowledge, opinions, and values.

Monitoring and follow-up. The recovery of the leopard in the Caucasus will be a long-lasting endeavour, and many of the parameters and variables tentatively important for the planning process are not sufficiently known. The parameters now considered to develop the plans – including economic conditions – will change over the years. Hence the conservation programme must employ adaptive management principles, regularly monitoring success and failure, and introducing new actions and measures to respond to new developments. Both the conservation strategy and the action plans must be revised on a regular basis – several years for the strategy, rather frequently for the national or sub-regional plans – in order to reconsider objectives, targets, and activities (Fig. 1). This implies the establishment of a standardised monitoring process allowing assessing the development of all critical parameters. Factors to be monitored include the development of the leopard population (distribution and abundance), the dynamics of the prey populations, and possibly human dimension aspects such as awareness, attitude, etc.

Strategic planning does not save a species – only successful implementation of conservation actions does. Yet, many action plans collect dust on shelves, and many conservation funds evaporate inefficiently because strategic planning and involvement of key institutions was neglected. Let us together make sure that this will not be the case for the leopard in the Caucasus.

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