Assessment of adverse human impact on biodiversity in Armenia's premier wilderness areas, Khosrov Reserve and Gndasar Mt./Noravank Canyon

Final report

Submitted by

Mr. Igor Khorozyan
Chairman
Youth Ecological Group/Armenian Leopard Conservation Society,
Yerevan, Armenia
E-mail: leopard_am@yahoo.com

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Contents.

I hereby confirm that all information provided hereinafter is correct to the best of our knowledge.

I. Khorozyan

1. SUMMARY.

This report derives from the field project generously supported by The Whitley Laing Foundation for International Nature Conservation/Rufford Small Grant program which was implemented in 4 months of summer-autumn 2002. The aim of this project was to assess the status and distribution of adverse human activities in the areas of both Khosrov Reserve and Gndasar Mt./Noravank Canyon and predict their actual or potential impact on the biodiversity. The seven large mammalian species were used as representatives of biodiversity which, due to their large body size and sometimes solitary life, demand for vast areas, often clash with people and respond very sensitively to human effects: leopard (*Panthera pardus*), brown bear (*Ursus arctos*), gray wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*), bezoar goat (*Capra aegagrus*), moufflon (*Ovis ammon*) and wild boar (*Sus scrofa*).

In our monthly field trips, all sites with evident human activities were recorded for geographical position by hand-held GPS device and further used for extensive GIS mapping and statistical analysis. As in the summer-autumn period human activities are most active throughout Armenia due to the maximum amounts of mature grass for livestock, edible biomass for people and honey-bearing vegetation for apiculture, we have arbitrarily supposed that this study embraces most of locally existing human sites and activities and thus provides a reliable state-of-the-art analysis.

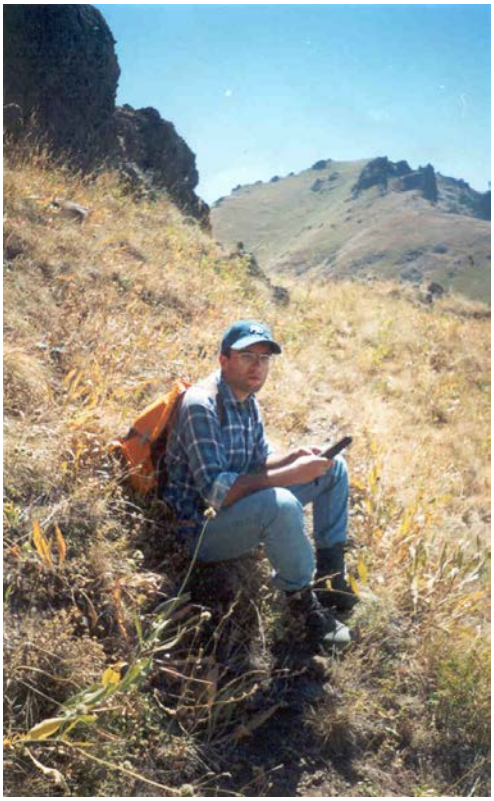

Fig. 1-1. The project author measuring a habitat parameter with hand-held GPS device. Photo by A. Malkhasyan.

Seven categories of human activities are described in as much detail as possible in this report: settlements (active and abandoned), roads (highways and dirt roads), livestock breeding (by livestock species and villages), biomass collection and hunting for food, apiculture, fish farming and deforestation. This information is in the text and depicted in 1 table, 5 photo pictures, 1 chart and 3 maps.

Information on the role of specific human activities on individual megafauna species is explained in the text and depicted in 2 tables, 2 photo pictures, 1 chart and 2 maps.

After the project description, we indicate the project results and output which include a scientific paper, international conference presentation and .pdf version of this report for free downloading from Internet. This is followed by further plans for research and conservation which list the priority issues in the study area. Two final sections of this report are acknowledgments to people who greatly assisted to me in this project and the list of references cited in the text.

2. STUDY AREA.

This project was carried out in summer-autumn 2002 in the area encompassing Khosrov Reserve and Gndasar Mt./Noravank Canyon area to the southeast which are located in SW Armenia. The former area accommodates all megafauna species studied by us as the key representatives of local biodiversity and the latter offers vital linkage for wildlife movements between the protected area and southern Armenia which, in its turn, is connected with northern Iran. The study area is depicted in Fig. 2-1 and its landscape characteristics and distribution determined from our GIS map are provided in Fig. 2-2 and Table 2-1. Its borders coincide with the range of local flagship, umbrella, keystone and indicator species – leopard (*Panthera pardus*) – so the maps hereinafter will indicate our study area as the "leopard range".

Khosrov Reserve, established in 1958, occupies the area of 258.6 km^2 (as in our GIS map) south-east of Armenia's capital Yerevan. It sits astride the south-western slopes of the Geghama ridge and has very steep relief: declivity <20^o makes 15%, 20-30^o - 19% and ≥30^o - 66% of total area. The territory is entirely an array of highland plateaus, volcanic massifs and mountain chains interspersed by very dense network of basic and branch gorges. The climate is dry continental, with hot summers (max. 38^{o}C) and cold winters (min. -25^{o}C). Vegetation period is 190-210 days per annum. Average annual precipitation is 400-600 mm, seldom up to 800 mm, maximum of which falls in April-June and minimum - in July-August. Main sources of water are Azat and Vedi rivers with tributaries, as well as numerous freshwater and mineral springs.

Fig. 2-1. Our study area in SW Armenia.

Vegetation is mainly xerophilic grasslands (64% of all coverage area), but contribution of thickets (20%) and sparse forests (16%) is also significant. Biodiversity of this protected area is very rich (Grigorian, 2000). Floristic composition comprises about 1800 species of vascular plants from 560 genera and 95 families, i.e. more than half of all plant species found in Armenia (3200). Vertebrate fauna is represented by 7 species of fish (23% of all recorded in the country), 5 amphibians (63%), 30 reptiles (57%), 130 birds (37%) and 40 mammals (48%) (Biodiversity of Armenia, 1999; Gabrielian et al., 1990).

The Gndasar Mt./Noravank Canyon area is much more arid than Khosrov Reserve and the scarcity of available water resources has been the principal factor limiting wildlife abundance and human activities in this region. Most of existing natural water sources are diverted through pipes to the places where people graze their livestock. Many sources completely dry out in hot summer season (May-October).

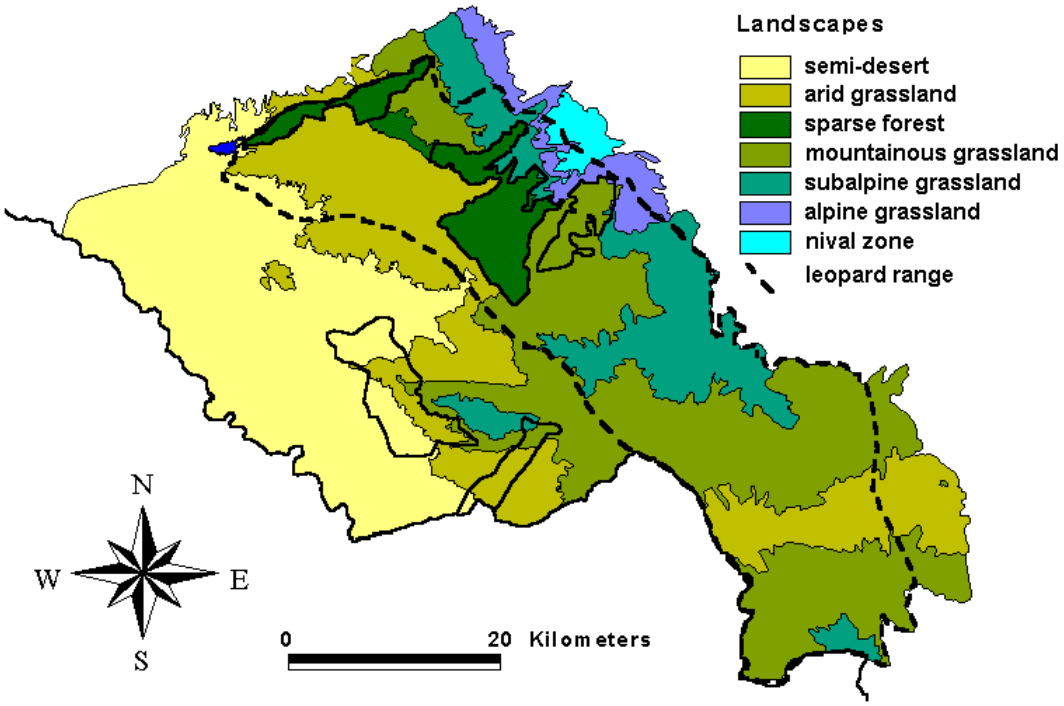

Fig. 2-2. Distribution of the landscape belts in our study area.

Most notably, Khosrov Reserve contains most (89.0%) of local forests which occupy rather limited area of Khosrov Reserve area and are present only as scattered remnants in Gndasar Mt./Noravank Canyon. This indicates its great importance in saving local forest ecosystem with its biodiversity and essential functions. Due to their historical significance, the forests have left in almost pristine condition since the times of King Khosrov III Kotak (330-338 A.D.) who declared this area a fully protected game sanctuary for himself. Until now, Khosrov Reserve remains the only large forest tract close to the capital Yerevan, it produces most of oxygen for local people and engenders all local streams and rivers giving water to people and nature. Fortunately, local forests have survived the severe energetic crisis which struck Armenia in early 1990s and caused large-scale deforestation in other parts of the country for meeting public demand in firewood.

Table 2-1. Distribution of landscape belts in Khosrov Reserve and Gndasar Mt./Noravank Canyon areas within the study area in Armenia.

Landscape belt	Elevation gradients, m	Khosrov Reserve area				Gndasar Mt./Noravank Canyon area	
		Total		Protected area			
		Area, km^2	%	Area, km^2	%	Area, km^2	%
Semi-desert	800-1200	22.6	2.9	-	-	-	-
Arid grassland	1200-1600	173.8	22.1	-	-	89.6	16.6
Sparse forest	1400-2300	139.6	17.8	124.2	79.4	-	-
Mountainous grassland	1600-2300	225.8	28.8	30.0	19.2	388.8	71.8
Subalpine grassland	2200-2600	180.0	22.9	1.4	0.9	62.8	11.6
Alpine grassland	2600-2800	33.4	4.3	0.8	0.5	-	-
Nival zone	2800-3200	9.3	1.2	-	-	-	-
Total	800-3200	784.5	100.0	156.4	100.0	541.2	100.0

3. HUMAN ACTIVITIES.

The main kinds of human activities in our study area are presented in Table 3-1. The sub-chapters which follow contain more detailed information about each item. The sources of data are either our estimates when no reliable statistical information is available (see Notes below) or as follows: our field work and GIS map – items 1, 2, 7, 8, 18-25 (all dated 2002); Department of Agriculture of Vayots Dzor Province Authority and the Ararat Department of Statistics and State Registry – items 3, 4 (2001), 9-17 (2002); Ministry of Nature Protection – items 5 and 6 (2002).

Table 3-1. The main parameters of human impact on the environment in our study area.

Items	Khosrov Reserve area		Gndasar Mt./Noravank Canyon	Total
	Total	Protected area		
1. Area, km^2	784.5	156.4	541.2	1325.7
2. No. villages	10 (all aband.)	2	16 (3 aband.)	26 (13 aband.)
3. Rural population	260[1]	50[1]	15944	16204
4. Rural density, ind./100 km^2	33.1[1]	32.0[1]	2946.0	1222.3
5. Guards, ind./100 km^2	6.1	30.7	N/A	30.7 in reserve
6. Budget, US$/ha	0.6	2.0	0	2.0 in reserve
7. Reserve infrastructure	6	2	N/A	6
8. Roads posts	10	4	N/A	10
9. Livestock No., including:	85-1051[2]	17-202[2]	16714	16799-17765
10. Cattle/milch cows	55-270/34-146[2]	11-52/7-28[2]	7392/4124	7447-7662/4158-4270
11. Sheep and goats	29-760[2]	6-146[2]	9123	9152-9883
12. Horses	1-21[2]	0-4[2]	199	200-220
13. Pastures, km^2	> 10.6[3]	unknown[3]	95.6	> 106.2
14. Livestock density, animals/ha:	< 0.1-1.0	very low	1.7	< 1.6-1.7
15. Cattle/milch cows	< 0.05-0.2/0.03-0.1	very low	0.8/0.4	< 0.7/0.4
16. Sheep and goats	< 0.03-0.7	very low	0.9	< 0.9
17. Horses	< 0.001-0.02	very low	0.02	< 0.02
18. Highways, km	44.7	8.8	75.0	119.7
19. Dirt roads, km	299.3	40.8	192.0	491.3
20. Highway density, km^{-1}	0.06	0.06	0.14	0.09
21. Dirt road density, km^{-1}	0.38	0.26	0.35	0.37
22. Shepherd camps	5	0	6	11
23. Bee hives	2	1	1	3
24. Fish farms	2	0	1	3
25. Poultry farms	1	1	0	1

Notes:

[1] These rounded estimates are based on the following mean values: 3 people per household in abandoned villages (used as summer pastures), shepherd camps, reserve infrastructure and farms; and 5 households per abandoned village, shepherd camp and farm.

[2] These ranges of estimates are based on rural population estimates given above and on the following minimum and maximum ratios of livestock heads per capita calculated for villages in Gndasar Mt./Noravank Canyon area: 0.21-1.04 for cattle, 0.13-0.56 for milch cows, 0.05-2.16 for sheep, 0.06-0.76 for goats and 0.001-0.08 for horses.

[3] Actual pastures are larger than areas of pastures in principal shepherd camps (Jringol, 7.6 km^2 and Almalah, 3.0 km^2), but to an unknown extent as livestock grazing in the abandoned villages is not managed.

3a. Human Settlements.

There are 26 villages located within our study area: 10 in Khosrov Reserve (including 2 inside Khosrov Reserve – Mangu and Agaslu) and 16 in Gndasar Mt./Noravank Canyon area. Half of these settlements are abandoned as previously they were inhabited by ethnic Azerbaijani who fled in early 1990s during Armenian-Azerbaijani war over Nagorno-Karabakh. They are mostly located around and in Khosrov Reserve and some of them – in Gndasar Mt./Noravank Canyon (Figs. 3a-1 and 3a-2). Despite abandoned villages do not have permanent population, they are occasionally used by shepherds from elsewhere as summer pastures for livestock. An example of the abandoned village inside Khosrov is depicted in Fig. 3a-3.

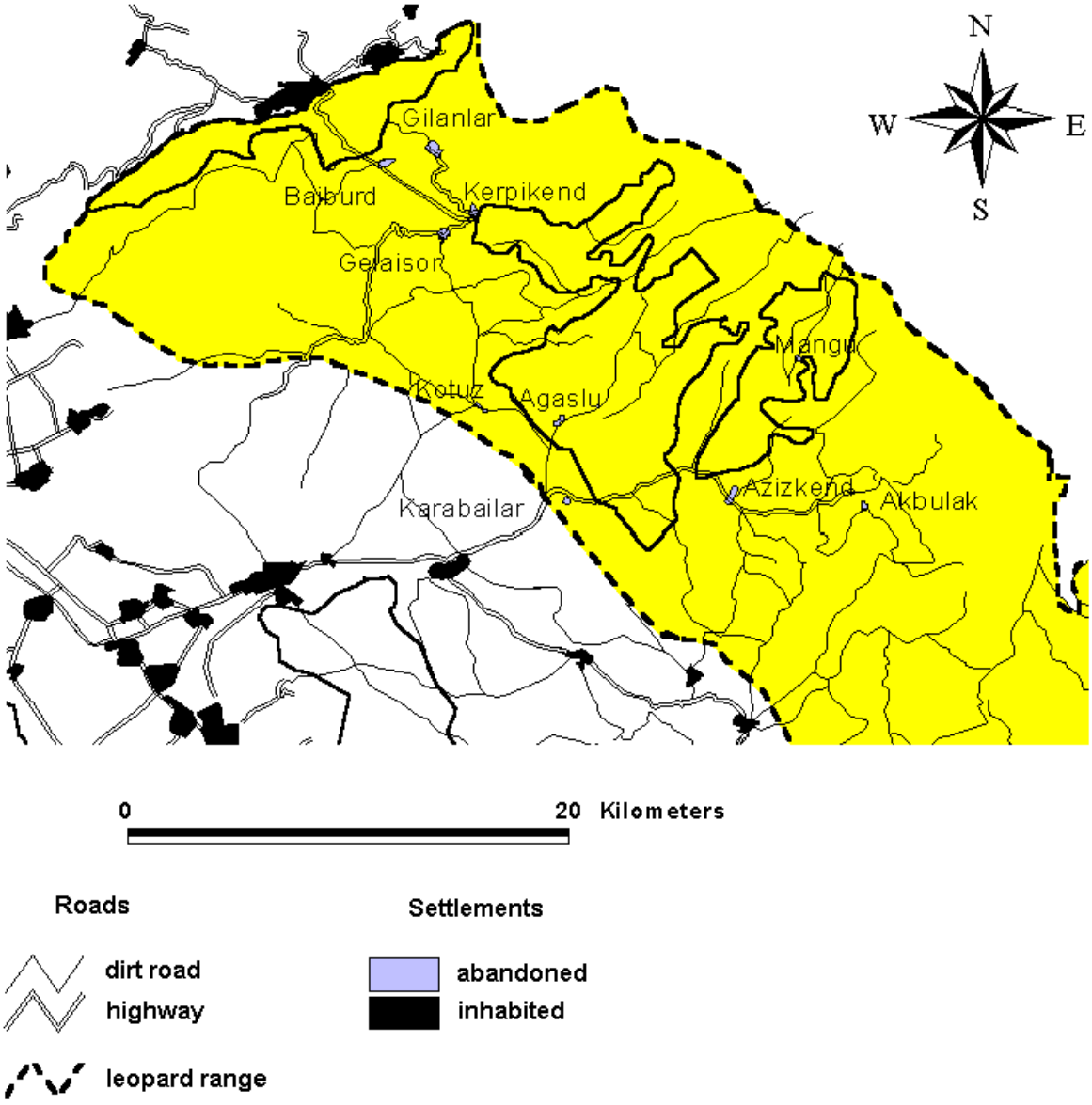

Fig. 3a-1. Location of human settlements and roads in Khosrov Reserve area.

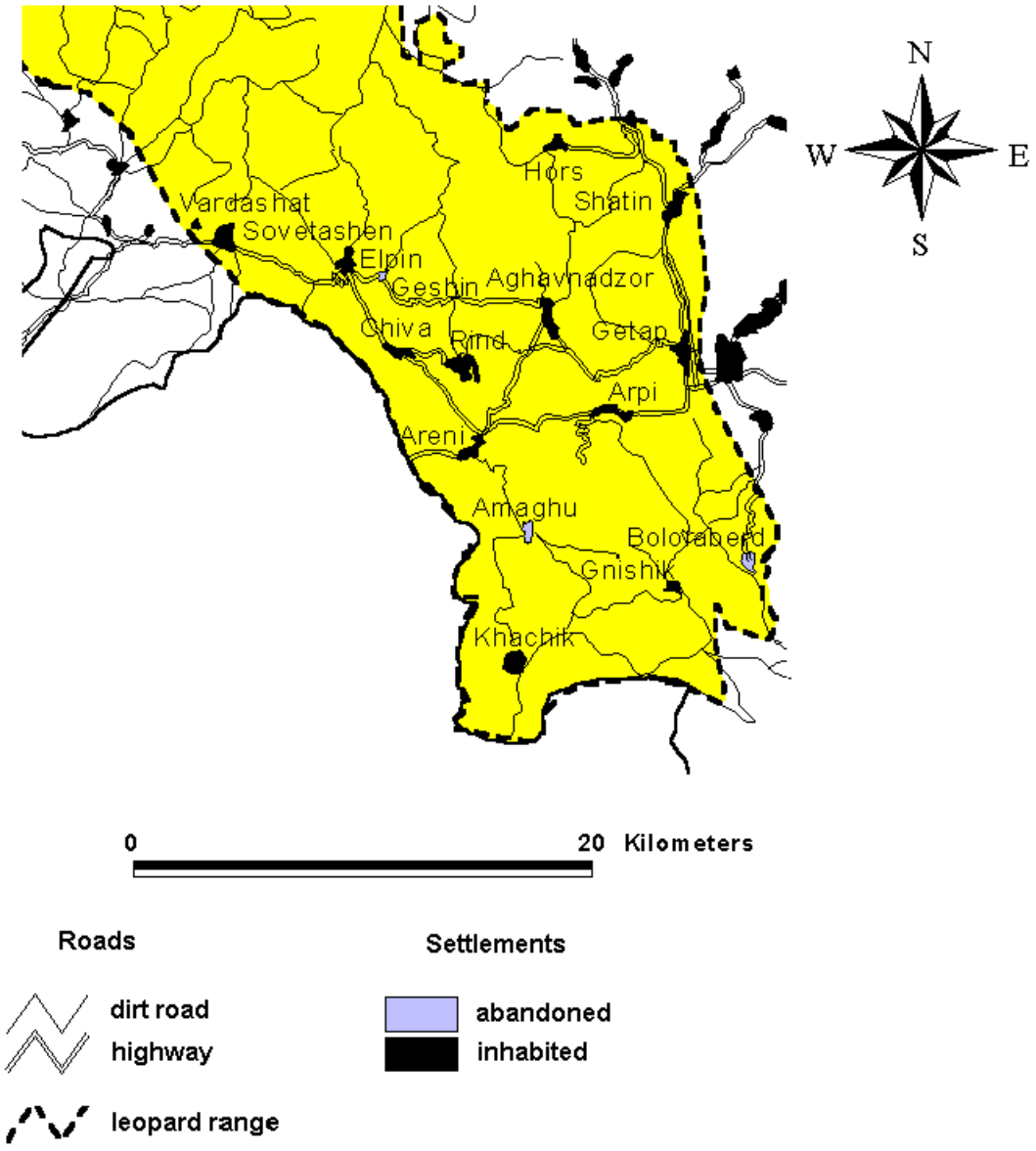

Fig. 3a-2. Location of human settlements and roads in Gndasar Mt./Noravank Canyon area.

The inhabited villages (located only in Gndasar Mt./Noravank Canyon area) contain from 209 people in Gnishik to 2275 people in Getap (mean 1226.5, SD = 652.5, n = 13) (Fig. 3a-2).

Fig. 3a-3. The abandoned village Mangu in Khosrov Reserve. On the front – semi-destroyed cross-stone, a religious symbol for Armenians. Photo by I. Khorozyan.

3b. Roads.

The roads - highways and dirt roads - in our study area are illustrated in Figs. 3a-1 and 3a-2. The highway density is more than twice as much in Gndasar Mt./Noravank Canyon than in Khosrov Reserve area, but the dirt road densities are almost equal (Table 3-1). This is caused by strong diversification of the nationally important highway connecting capital Yerevan with southern Armenia in the former area. Generally, this highway is of good quality but a part of it has been periodically destroyed by landslides and reconstructed. The newly constructed highway along the bottom of the Noravank Canyon which provides access to the favorite local tourist destination, Noravank Monastery complex of XII century, is shown in Fig. 3b-1. In Gndasar Mt./Noravank Canyon area, the dirt roads are in much better condition and thus more destructive to ambient environment than in Khosrov Reserve area because of their frequent and intense use by rather numerous rural population (densities 2946.0 vs. 33.1 people/100 km^2; Fig. 3b-2).

Fig. 3b-1. The highway in Noravank Canyon. Photo by I. Khorozyan.

Khosrov Reserve holds 19.7% of highways and 13.6% of dirt roads present in Khosrov Reserve area. It has the same highway density as the whole area as a result of two main asphalted highways giving access to the key reserve infrastructure for reserve staff and, if necessary, for scientists. Meanwhile, the density of dirt roads is by 1.5 times lower than in the area ensuing from seldom use of extremely rough terrain by the reserve's off-road vehicles – local mountains are best to be surveyed on horseback which does not essentially require the presence of dirt roads.

Fig. 3b-2. The dirt road network in Gndasar Mt./Noravank Canyon. Photo by I. Khorozyan.

In comparison with 93 protected areas surveyed in 22 tropical developing countries, Khosrov Reserve has almost four times higher human density (32.0 people/100 km^2 vs. mean 8.9, range 0-5718) (Bruner et al., 2001), but it seems insignificant on the background of generally very high human density in Armenia, particularly in Ararat province where this reserve is located (14400 people/100 km^2).

3c. Livestock Breeding.

Breeding of cattle, sheep and goats has been the most important agricultural activity in our study area which is carried out around the villages or, when local pastures are overgrazed, at the seasonal shepherd camps located at the higher elevations in grasslands (Fig. 3c-1). As we have official information on livestock distribution only in Gndasar Mt./Noravank Canyon area and these data are used as a basis for assumptions on livestock in Khosrov Reserve area, the following information reflects situation in the former area and is supposed to be similar in the latter.

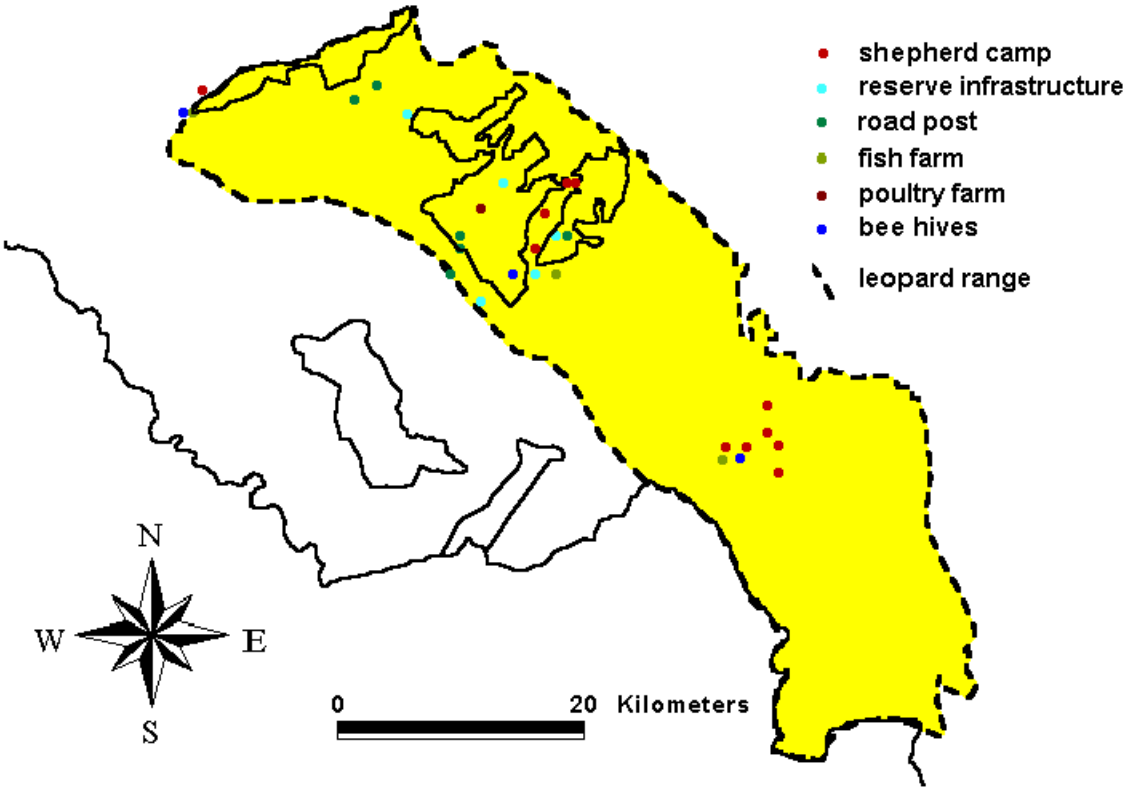

Fig. 3c-1. Location of human activity sites in our study area (except the roads and settlements).

Milch cows make 58.1% of all local cattle (range 49.2-80.3, SD = 8.8, n = 13), whereas cattle and small livestock (sheep and goats) are almost equally important species bred. Villages with dominating cattle are Chiva (70.2% of all livestock), Getap, Rind (61.4), Areni (54.9) and Elpin (51.7). Villages with dominating sheep and goats are Gnishik (79.1% of all), Hors (74.8), Khachik (71.4), Vardashat (69.6), Sovetashen/Zangakatun (63.8) and Shatin (52.9). Villages with equal proportions of cattle and sheep and goats are Arpi (50.5% and 48.2%) and Aghavnadzor (49.0% and 49.1%). Pastures make mean 7.4 km^2 (range 1.5-17.3, SD = 4.7, n = 13) per village.

The following conclusions can be made on individual villages:

1. The villages Aghavnadzor, Arpi and Shatin have the highest livestock densities which indicate very significant levels of load on pastures. Importantly, these three villages hold large stocks of sheep and goats known to cause the highest possible damage to natural vegetation.
2. The villages Gnishik, Hors, Sovetashen/Zangakatun and Vardashat have the highest numbers of livestock per capita of local rural community what can indicate the top levels of possible saturation of local pastures with domestic animals. All these villages have dominating stocks of sheep and goats over the cattle, adding to strong adverse impact on local grassland environments.
3. According to classification of Singh (2001) and 4-grade system of A. Bruner (pers. data), the densities of all livestock species can be regarded as medium to high in Gndasar Mt./Noravank Canyon area and as low to very low in Khosrov Reserve area.

Below, we provide information on distribution of livestock per village (n = 13) (Fig. 3c-2).

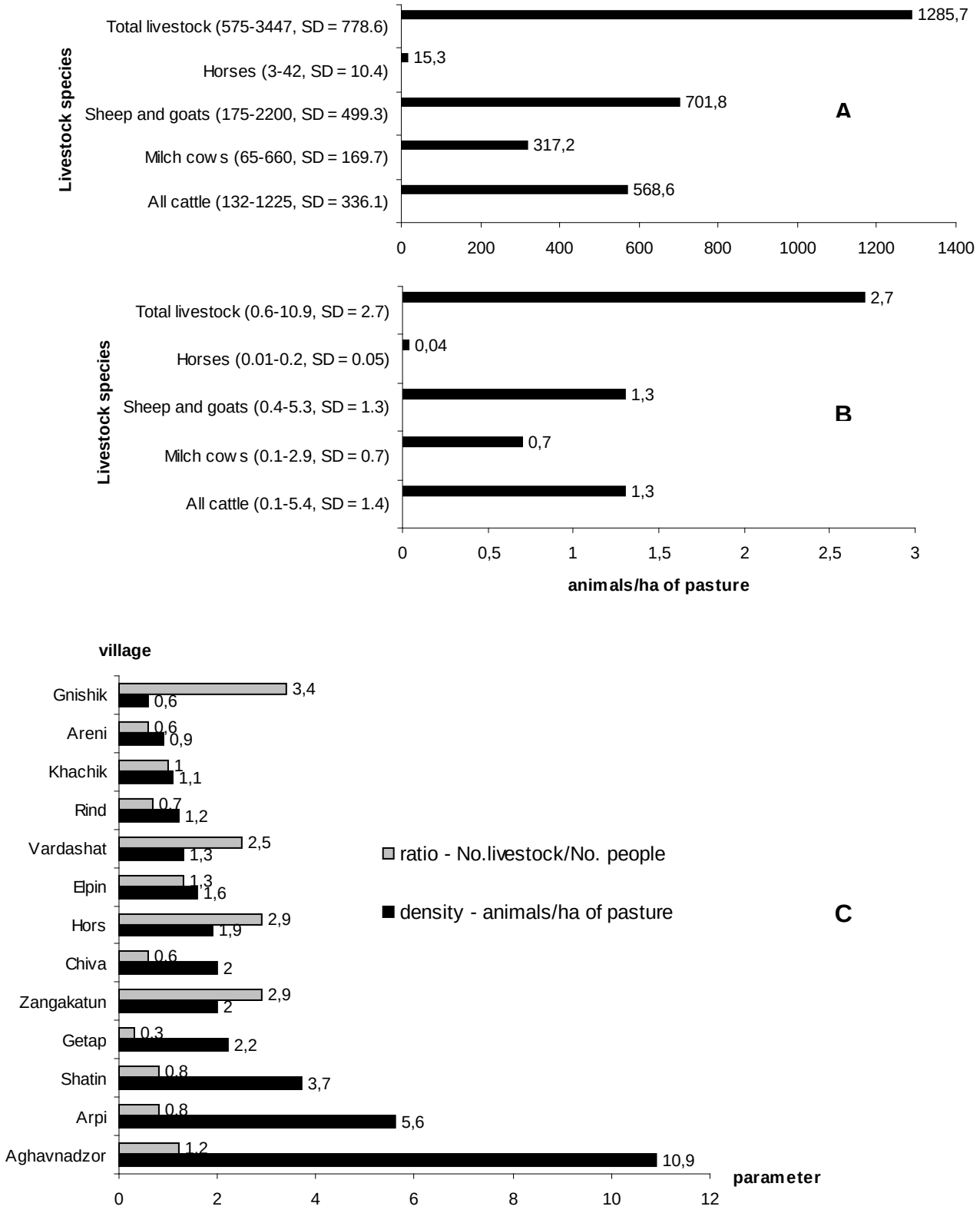

Fig. 3c-2. Distribution of livestock in villages: A – mean number per village; B – mean density per village; C – density and per capita ratio in villages.

In Khosrov Reserve itself, livestock densities are very low – lower than in Khosrov Reserve area, not saying about Gndasar Mt./Noravank Canyon area – because no shepherd camps are located inside it and the livestock present in protected area penetrate from shepherd camps or abandoned villages (= pasture grounds) situated close to reserve border within the buffer zone, mainly Jringol and Almalah (Armenian and Kurdish Yezdi) camps in eastern part of Khosrov.

Grazing continues from May to October or even to November if autumn is warm enough. Sheep are more tolerant to colds than cattle and they stay longer periods at the ridge plateaus.

Different effects of grazing depend on livestock species involved. Sheep nibble the vegetation to a uniform sward (like mowing) while their scattered feces have little impact on soil ecosystem. As a result, this practice favors low-quality monocotyledonous plants (grasses) which grow from basal meristems and depresses abundance of palatable dicotyledonous species (herbs) growing largely from apical meristems. Highly agile goats are environmentally most destructive agents which can completely trample down and deforest a certain area in quite a short period of time. Cattle pull clumps of vegetation, often break the sward with their hooves and their cow pats kill these plants that are smothered but enrich the nearby sward.

Fig. 3c-3. An example of grassland and arboreal vegetation depressed by livestock grazing in Gndasar Mt./Noravank Canyon. Photo by I. Khorozyan.

Trampling brings about intense soil erosion, especially when soil is dry (as in dry subtropics of Armenia) and this is dependent on livestock species and age group: cattle are heavier than sheep and goats, goats are more active than cattle and sheep and calves are more active in grazing than adults (Sutherland, 2000). An important factor is the place of grazing: on slopes where local cattle graze, even slight grazing intensifies wind and water soil erosion without affecting plant communities, whereas on plateaus (sheep pastures) it reduces availability of feeding grounds through diminution and fragmentation of vegetation cover (Bertiller, 1996).

Grazing significantly destroys woody vegetation which is most vulnerable to trampling if compared with herbaceous and other life forms of plants (Sun & Liddle, 1993). This is very evident in the typical mountainous landscape of Gndasar Mt./Noravank Canyon area: large tracts of grassland are overgrazed and the remnants of forest are looking weak and poorly viable (Fig. 3c-3). For comparison, Khosrov Reserve still holds large areas of pristine deep woods where the brown bears (*Ursus arctos*) and wild boars (*Sus scrofa*) thrive (Fig. 3c-4).

Fig. 3c-4. Deep broadleaf deciduous forest in Khosrov Reserve. Photo by I. Khorozyan.

Intense livestock grazing causes local climate warming due to removal of vegetation which would consume solar energy for photosynthesis. This phenomenon results in increased air

temperatures, water scarcity and soil dryness; in its turn, such desertification itself accelerates climatic warming and aggravates landscape degradation towards the prevalence of arid shrubby ecosystems (Balling, 1992). Apart from these changes, the occurrence of wild fire will also increase in areas where conditions become warmer and drier (Clark, 1991) and this aspect is highly relevant to biodiversity, particularly large predator, conservation in Khosrov Reserve and adjacent areas (Khorozyan & Malkhasyan, 2002).

There is a great uncertainty with the effect of climate warming on ecosystems in Khosrov Reserve and Gndasar/Noravank areas. According to the First National Communication … (1998), this area has experienced insignificant increase of air temperatures (0-0.5 C^o) in the 20th century, but local precipitation decreased by 15.9% in the same time frame. Also, the maps of present and forecast landscape changes in Armenia show no significant differences other than some expected encroachment of semi-desert to grassland in western part of Khosrov Reserve which is inherently dry.

3d. Biomass Collection & Hunting for Food.

Collection of edible plant biomass (herbs, mushrooms, fruits and berries) takes place every year from April to October both in Gndasar Mt./Noravank Canyon and, what is sad to say, in Khosrov Reserve area. The people involved in this procedure come from the villages nearby; they are mainly young and physically strong men, but women can also be seen while gathering.

Hunting is quite frequent and undertaken as short-term field trips for killing locally abundant small wildlife, e.g. European hares (*Lepus europaeus*) and chukars or stone partridges (*Alectoris graeca*), for food. Sometimes, the leg snares are set for the bezoar goats (*Capra aegagrus*) and wild boars (*Sus scrofa*) and these ungulates will be readily shot if encountered. Hunters (and often green biomass gatherers) stay overnight in caves and may disturb the bezoar goats and leopards (*Panthera pardus*) living in precipitous rocky environment and shoot them on sight. The notorious “high rank hunts” organized for the leisure of VIP are sometimes occurring, but most often they are limited by picnics in some lodge or wonderful scenery as the visitors do not have enough physical capabilities and enthusiasm for hiking over local mountains.

This category of illegal activities is most widespread and, at the same time, most difficult to detect. Hence, our map (Fig. 3c-1) does not contain information about it. Even though we observed trespassers by binoculars many times, we were unable to measure their position by GPS device due to long time needed to move from one place in extremely rugged landscape to another one where intruders stand.

The principal reason of existence of this problem is that local reserve rangers, even though quite numerous (Table 3-1; compare guard density in Khosrov Reserve, 30.7 ind./100 km^2 vs. mean 1.7, range 0-200 ind./100 km^2 in 93 protected areas of 22 tropical developing countries (Bruner et al., 2001)), they do not have economic motivation to patrol their land tenures and catch the trespassers red-handed. The mean wage of Khosrov Reserve ranger is ca. $23.8/month (as in August 2002). This figure derives from general financial insufficiency of reserve protection capacities ($2.0/ha, compare with mean 1.3, range $0-50 in Bruner et al. (2001)). As a result, reserve rangers living in the same villages as the green biomass collectors and hunters experience the same dire poverty and understand that just an instinct of survival drives rural people to search for food inside protected area.

3e. Apiculture.

We have found and mapped three apicultural farms in our study area: two in Khosrov Reserve area and one in Gndasar Mt./Noravank Canyon area (Fig. 3c-1). One farm is located within the reserve's buffer zone.

Apiculture is developed at the lower elevations where there is sufficient water supply, lush honey-bearing vegetation and higher air temperatures supporting bee activities. This activity is very sensitive to weather: for example, in 2002 it gave good yield of honey due to strong rainfalls in spring 2002 which produced rank vegetation. Usually, the yields are just enough to support apiculturists and their families who sell honey at marketplace.

3f. Fish Farming.

This activity is also limited by lower elevations having plenty of streaming water. We have found just three sites, two in Khosrov Reserve area and one in Gndasar Mt./Noravank Canyon area. The main place of fish farming in the region is Azat Reservoir located at the extreme north-west of Khosrov Reserve. The fish produced locally are brook trout (*Salmo trutta*), Armenian endemic Sevan trout (*Salmo ischchan*), silver carp (*Hypophthalmichthys molitrix*) and goldfish (*Carassius auratus*).

3g. Deforestation.

The remnants of forest have been intensively cut by villagers outside Khosrov Reserve and in Gndasar Mt./Noravank Canyon. Logging takes place seasonally in late autumn specially to prepare firewood for cooking and household heating in winter time. In Khosrov Reserve itself, logging is prohibited and stringently controlled by its directorate. Only dead wood (trunks and pruned branches) are collected to be used by reserve staff in winter in strict quota 3 m^3/person/winter. Amounts of naturally dried wood biomass is significant in Khosrov Reserve due to periodical droughts and, what is seldom, fire. Walker (1994) claims that removal of dead wood may produce repercussions on community ecology, since the dead wood makes an important component of nutrient cycles and habitats for detritivorous organisms (arthropods, etc.), but we leave this statement without comments since nobody ever studied this aspect in our country.

4. IMPLICATIONS FOR MEGAFAUNA CONSERVATION.

4a. Leopard (*Panthera pardus*)

Together with moufflon (*Ovis ammon*), the leopard shares the reputation of being the most charismatic and the rarest large mammalian species of Armenian fauna listed as "endangered" in the national Red Data Book and in 2000 IUCN List of Threatened Species. It lives constantly in southern Armenia (Zangezour ridge) which is tightly linked with northern Iran and also penetrates to Khosrov Reserve as its extreme north-western margin of range via Gndasar Mt./Noravank Canyon area which serves a movement corridor. Another possible corridor is Kyarki area south of Khosrov Reserve from where the leopards may enter Azerbaijan's Nakhichevan Republic, but the Armenian-Azerbaijani border guards may shoot migrating individuals (Fig. 4a-1). So, Gndasar Mt./Noravank Canyon area remains the principal movement conduit for local leopards which allows exchange of individuals and thus raises viability of population.

Existence of just this corridor for local leopards is determined by continuous habitat (sparse forest and grassland along the ridge tops) and barrier-free southeastward direction of the ridge tops through which the leopards move. As found in the Iberian lynx (*Lynx pardinus*), habitat fragmentation and location of important barriers are principal factors dictating the dispersal and corridor use patterns in the felids which would compromise the increased mortality of dispersing subadults (Ferreras, 2001).

This movement corridor may ensure the "rescue effect" if a metapopulation goes extinct in one patch of a fragmented habitat while other patches retain substantial numbers and thus prevent extinction. However, if animals go extinct simultaneously in all patches, the "rescue effect" is impossible and the corridor will actually synchronize local extinctions in inter-connected patches and accelerate the species die-off (Earn et al., 2000).

As studied previously by us (Khorozyan & Malkhasyan, 2002), local leopards feed overwhelmingly on bezoar goats (*Capra aegagrus*) which enjoy stable and high population size in Khosrov Reserve, and opportunistically on plentiful European hares (*Lepus europaeus*). The critical habitat is the sparse forest with precipitous and often inaccessible cliffy massifs where dominating plant species are evergreen junipers (*Juniperus* spp.) and, to a lesser extent, deciduous almond (*Amygdalus fenzeliana*) and pears (*Pyrus* spp.). This is not a typical forest as people usually perceive it: trees are crooked and standing at distance from each other, never forming closed canopy. The cliffs are used by leopards for rest, hunting and breeding. This landscape is present along the ridge tops where the leopards find optimal straightforward trails to move through the vast territories for quite a short time and easily spot prey grazing beneath from the vantage watch posts at the cliff brinks. Towards the canyon bottom with streams flowing alongside, this sparse forest transforms to the dense "jungles" or true woods made of oak (*Quercus macranthera*), oriental beech (*Fagus orientalis*), crooked and thorny berry trees and scrubs like buckthorn (*Rhamnus pallasii*), dog rose (*Rosa canina*), hawthorn (*Crataegus calycina*), wayfaring tree (*Viburnum lantanai*), etc. where dominating large mammals are brown bear (*Ursus arctos*) and wild boar (*Sus scrofa*). Other habitats where we found the leopard scats (arid, mountainous and subalpine grasslands) are seemingly used by local leopards opportunistically only for movements between the blocks of the sparse forest. Semi-deserts, alpine grasslands and nival zone are definitely ignored by local leopards (Fig. 4a-2).

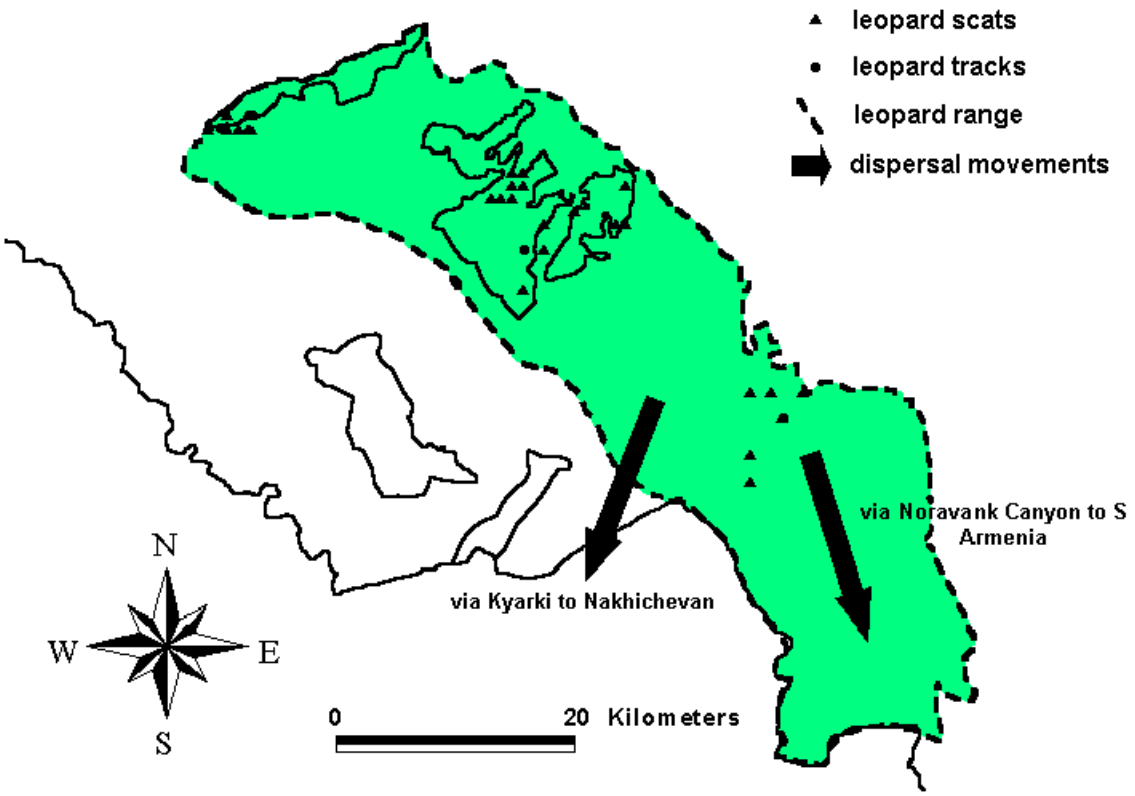

Fig. 4a-1. The leopard range, scat and track sites found by us and movement routes in our study area.

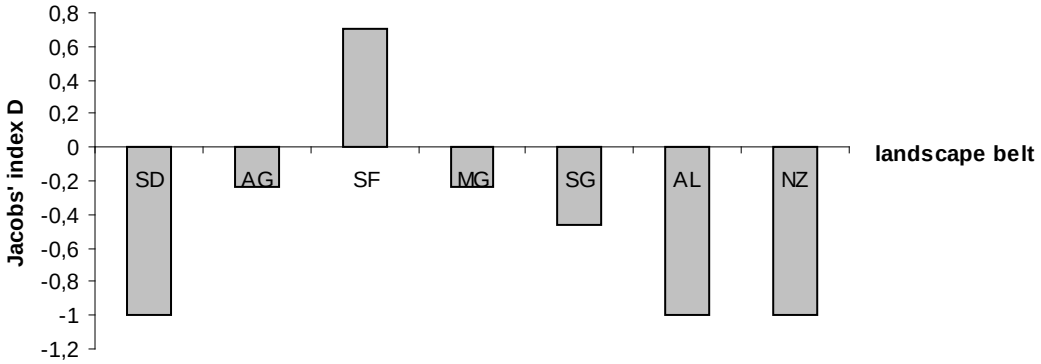

Fig. 4a-2. Distribution of Jacobs' habitat preference index D for *P. pardus* over the landscape belts in Khosrov Reserve. Abbreviations: SD – semi-desert, AG – arid grassland, SF – sparse forest, MG – mountainous grassland, SG – subalpine grassland, AL – alpine grassland, NZ – nival zone.

Our main concern over the long-term viability of the leopard in our study area rests on low environmental awareness of local people about this magnificent cat and on its conflict with people for space. For example, we have statistically estimated that leopard distribution is significantly different from location of reserve infrastructure and road posts, but shares the same elevations and habitats with livestock breeding areas (Table 4a-1).

Table 4a-1. Altitudinal separation of leopard signs and human sources in Khosrov Reserve and Gndasar Mt./Noravank Canyon areas. Abbreviations: T – tracks, S – scats, RI-RP – reserve infrastructure and road posts, ShC – shepherd camps, NS – difference is statistically non-significant.

Pairs of compared samples	Area	95% confidence limits of difference between sample means
Leopard T and S vs. RI-RP	central Khosrov Reserve	417.8-804.4 m, df = 15, $p < 0.001$
Leopard S vs. ShC	eastern Khosrov Reserve	NS
Leopard S vs. RI-RP	eastern Khosrov Reserve	333.2-1090.6 m, df = 12, $p < 0.05$
Leopard T and S vs. ShC	Gndasar Mt./Noravank Canyon	NS

As shown on Table 4a-1, the leopard lives at higher elevations, more precisely by 300-1000 m higher, than reserve staff does and this difference is statistically significant: mean elevation of the occurrence of leopard scats and tracks is 2164.5 m in eastern Khosrov Reserve and 2074.0 m in central Khosrov Reserve, whereas local reserve infrastructure and road posts are located at means 1528.1 m and 1442.0 m, respectively. This does not essentially mean the avoidance of humans and retreat to higher elevations, as we do not hold any evidence that the cats were once living in other habitats at altitudes occupied now by reserve people and were then pushed upwards to the sparse forest under pressure.

An important factor of risk to the leopard and all other megafauna species in Khosrov Reserve is the "edge effect", i.e. increased chances of animals to be shot along the reserve border by villagers from the ambient agricultural lands. It is caused by separation of reserve territory into 5 isolated districts with highly curved border lines (high ratios district perimeter to district area) which force very mobile leopards and other species to easily move from protected area to its unprotected vicinities and back (Table 4a-2).

Table 4a-2. The "edge effect" in Khosrov Reserve as measured by the reserve perimeter/area ratio. The "edge effect" ranking: H – high, M – medium.

Reserve district	Reserve perimeter, km	Reserve area, km^2	Perimeter/area ratio, km^{-1}	"Edge effect" ranking
Garni, N Khosrov*	46.3	33.1	1.40	H
Khachadzor, E Khosrov*	39.1	30.9	1.26	H
Urtsadzor, S Khosrov	31.8	25.7	1.24	H
Khosrov, central Khosrov*	82.7	92.4	0.89	H
Western	49.1	76.5	0.64	M
Total	249.0	258.6	0.96	H

Note: The districts where the leopards live are marked by asterisk *.

Another important threat to the leopards ensues from human activities – hunting and disturbance of staple prey species (for details, see sub-chapter 3c. Livestock Breeding and 3d. Collection of Biomass & Hunting for Food).

Regarding the status of Gndasar Mt./Noravank Canyon as a corridor for leopards and other wildlife, the principle constraint here is the presence of the nationally important highway connecting Yerevan with southern Armenia and Iran. As this corridor experiences acute shortage of water resources available to wild animals, the best source is Arpa river, but it flows along this highway and makes animals very cautious to come here at daytime and become visible to humans. However, we know several cases of seeing subadult leopards by drivers while crossing this highway during dispersal.

Recently, in an official report to WWF-Caucasus and several publications we have suggested the following essential measures to make the leopard conservation in our study area and whole Armenia workable (Khorozyan, 2001, 2002; Khorozyan & Malkhasyan, 2002). As the leopard is the flagship, indicator, keystone and umbrella species of local ecosystem, its protection will embrace all other megafauna species considered in this report as well. These measures are the following:

1. Acquisition of surrounding agricultural lands for enlargement of existing protected area.

2. Maintenance of natural corridors linking Khosrov Reserve with southern Armenia through which the leopards and other wildlife could move (Gndasar Mt., Noravank Canyon and Kyarki) and the corridor between Armenia and Iran (state border).

3. Stringent control of the status of the “buffer zones” fringing the reserve border and accumulating most shepherd camps and other sites of human activities.

4. Control of livestock grazing and elimination of free roaming over the leopard and bezoar goat habitats.

5. Development of ecotourism, ecodevelopment (e.g., marketing of local handicrafts with leopard logo) and anti-poaching projects and protection enforcement programs, i.e. efforts oriented to creation of economic motivation for local villagers to avert them from using reserve’s biological resources and for the rangers to curb illegal activities.

6. Development of educational campaigns providing to local communities (villagers and border guards) more knowledge about the leopard and ambient environment and thus raising public awareness about the value of this carnivore for nature and people.

7. Control of wild fire in the sparse juniper forests of Khosrov Reserve and other areas of Armenia. The junipers and other xerophylic vegetation of local ecosystems contain minimum amounts of water in tissues and can burn down over the vast areas from a single dropped cigarette, match or piece of glass. Control and timely firefighting are extremely difficult in local mountains due to insufficient resources.

4b. Brown bear (*Ursus arctos*)

The brown bear is represented in Armenia, particularly in our study area, as two subspecies: common brown bear (*U.a. arctos*) and Syrian bear (*U.a. syriacus*). The first of them is typically brown and large, whereas the second is light beige or straw-colored and looking more slender (Fig. 4b-1). Both these subspecies peacefully co-exist together, share the same woody habitats and possibly inter-breed to produce hybrids.

The favorite habitats for local bears are deep forests located along the water courses in gorge bottoms and made of fruit and berry trees and scrubs (Figs. 3c-4 and 4b-2). Hence, their food is absolutely vegetarian and consisting of fruits, berries, herbs and roots.

Brown bears are very common in Khosrov Reserve, as we found their feces and observed themselves in natural environment very frequently. In Gndasar/Noravank, however, the bears deceptively seem to be common (frequent sightings near human settlements), because insufficient food resources and water in heavily fragmented forest remnants drive

them to visit human sites (shepherd camps and bee hives) for feeding and drinking and the increased visitation rates intuitively create an image of bear commonness.

Local people respect the bears and like to tell the stories of seeing a mother bear playing with cubs on a glade or how the bears visited an orchard last night (this is very common in local villages in autumn season). They never shoot these carnivores, but feel more self-assured in mountains if holding a firearm against a possible bear attack – local bears are usually peaceful and even grazing side by side with domestic livestock, but sometimes they can be very aggressive and suddenly maul a man, especially if accompanied by cubs.

Fig. 4b-1. A Syrian brown bear in Khosrov Reserve. Photo by A. Malkhasyan.

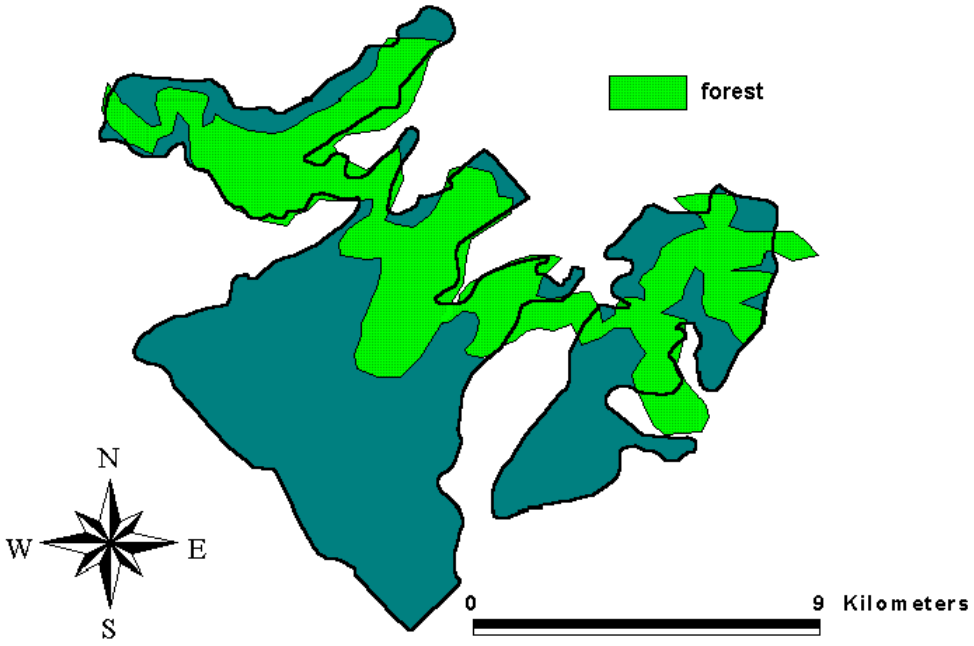

Fig. 4b-2. Distribution of broadleaf deciduous forests in Khosrov Reserve area, the habitat for brown bears (*Ursus arctos*) and wild boars (*Sus scrofa*).

Khosrov Reserve was specially established to protect as large tracts of local forests as possible, hence local bear population is doing well. In contrast, population in Gndasar Mt./Noravank Canyon looks depressed and poorly viable – meager fecal samples found by us provide some evidence of that. The only possible threat to this species is associated with deforestation and destruction of forests by livestock grazing (Fig. 3c-3). Some competition with people exists during the period of collection of tasty bulbous-rooted chervil (*Chaerophyllum bulbosum*) and species (*Falcaria vulgaris*). Collection season is April-June in lowlands (1000-2000 m) and July-August at higher elevations (> 2000 m), after that these plants stiffen and become unpalatable.

4c. Gray wolf (*Canis lupus*)

The gray wolf is very common in grasslands where it feeds principally on grazing livestock, mainly calves, sheep and foals. By the middle of autumn when shepherds and livestock start to return to their home villages from high-elevation pastures and thus wolves lose their normal prey base, they descend to lower elevations and cause substantial damage to wild boars (*Sus scrofa*). In winter time, they often enter villages, attack people and steal dogs.

Abundance of wolf has been an objective factor as claimed by local rural communities and reserve rangers. In mid-1990s, a campaign was launched to cull predators from helicopters, but this effort was unproductive as local mountainous conditions often pose danger to flight safety and the wolves quickly recovered to their former levels. During our field trips, we heard frequently the requests to adopt a strategy of wolf control which would alleviate pressure on local animal husbandry and human safety, but this would require substantial financial inputs. Moreover, this effort should be well analyzed “pros and cons” and ecologically justified before initiation to avoid the destruction of natural balance in ecosystems. For example, a possibility should be kept in mind that curbing the wolf numbers may result in increase of wild boar population which is likely to be struck by outbreak of some disease (as a self-regulating mechanism) and this infection will affect human population living downstream the riparian forest habitats of boars (Kelegian, 1995). Moreover, actual wolf numbers can be easily overestimated by double-counting of highly mobile packs (Walker, 1994).

4d. Eurasian lynx (*Lynx lynx*)

Eurasian lynx is common throughout the sparse juniper forests and grasslands both in Khosrov Reserve area and in Gndasar Mt./Noravank Canyon area. It feeds principally on European hares (*Lepus europaeus*) and rodents (Khorozyan & Malkhasyan, 2002), thus having its own separate ecological niche in ecosystem. Among the megafauna species considered by us in this report, the lynx appears to be least affected by and independent on human activities as leading crepuscular or nocturnal lifestyle and preying on abundant small wildlife. The only possible threat to the lynx existence would be trampling of rodents, ground-nesting birds and other small animals by grazing livestock, but there is no any sign of this effect.

4e. Bezoar goat (*Capra aegagrus*)

The bezoar goats live in the same habitats as the leopards described above. They are in good condition in Khosrov Reserve, as we many times found their pellets and hoof tracks and frequently observed adult groups and female-kid flocks, especially in morning and evening hours (Fig. 4e-1). The good indicators of their well-being can be high occurrence of relatively big groups (5-18 animals) of all sex/age categories and of kids and young individuals in groups (on average, 2 kids per female). We very seldom observed the females without kids, possibly indicating high reproduction rates in population.

In contrast, Gndasar Mt./Noravank Canyon area holds small numbers of goats as we found insignificant numbers of pellets and saw only few individual goats in small groups without kids which fled from us in great scare. Obviously, human pressure and stress factors in local bezoars are high.

The most important negative factor to this herbivore throughout the study area, especially in Gndasar Mt./Noravank Canyon area, is disturbance caused by loud whoops of shepherds who sally out to the mountains in evening time and search for their scattered livestock to herd them together and drive back to the stalls for night. As local wildlife feed principally at the morning and evening hours, such shepherds' shouts bring much annoyance to the animals. Also, an important negative factor is poaching – shooting and setting leg and neck snares at the entrances to caves where the goats like to rest.

Fig. 4e-1. The bezoar goats in Khosrov Reserve. Photo by A. Malkhasyan.

4f. Moufflon (*Ovis ammon*)

Like the leopard, moufflon is the rarest megafauna species in the country, numbering maximum a few dozens of individuals within a range from west of Khosrov Reserve to Armenian-Iranian border on the south. About 15 animals live seasonally in the grasslands of Urtsadzor area in western part of Khosrov Reserve lying outside of our study area. These moufflons immigrate every year in spring from Azerbaijan's Nakhichevan Republic and move back in autumn. The reason of such movements is good quality of grasslands in Armenia and warmer winter in Nakhichevan which determines longer foraging season there. Migrations inevitably cross the state border where guards relentlessly shoot them on sight.

4g. Wild boar (*Sus scrofa*)

The wild boars are very common and even abundant in the riparian tall grass and forest ecosystems of Khosrov Reserve area (Fig. 4b-2). In contrast, Gndasar Mt./Noravank Canyon area holds insignificant numbers of these animals, if any, due to arid climate with lack of appropriate water-rich ecosystems and strong pressure of hunting.

5. PROJECT RESULTS & OUTPUT.

Project output will include publication in peer-reviewed scientific journal *Biological Conservation* and presentation at 3rd International Wildlife Management Congress in New Zealand in December 2003. If allowed by copyright and other relevant conditions of the Rufford Small Grant program, this report will be converted to .pdf format, distributed electronically throughout the world among our friends and colleagues and posted at our website www.persianleopard.com for free download. By the end of the year 2002, this website will be updated to include information about this project. To facilitate the involvement, responsibility and awareness of local conservation authorities and public, this report is already translated into native language and presented to the Ministry of Nature Protection of the Republic of Armenia and the Institute of Zoology, National Academy of Armenia.

Financial support provided by The Whitley Laing Foundation for International Nature Conservation/Rufford Small Grant program for implementation of this project is properly acknowledged in the translated version of this report presented to Armenian authorities and scientists and it will be clearly indicated thereafter in all resulting publications, in personal correspondence and communication.

6. FURTHER PLANS FOR RESEARCH & CONSERVATION.

Further research and conservation actions are urgently needed to incorporate the following priority issues:

1. Effect of livestock grazing on local ecosystems and especially on forests.

2. Assessment of green biomass collection and hunting on biodiversity.

3. Enforcement of protection regime through mobilization of existing human resources (guards) and logistics (ammunition, off-road vehicles and firearms) and fundraising for covering field expenses and local involvement.

4. Establishment of anti-poaching squads to curb poaching. This issue is closely related to the previous item “Enforcement of protection regime”.

5. Environmental education in village schools and among adults in shepherd camps, abandoned villages (= pasture grounds) and farms.

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