A PROGRAM FOR REINTRODUCTION OF THE FAR EASTERN LEOPARD INTO SOUTHERN SIKHOTE-ALIN, PRIMORSKY KRAI, RUSSIAN FAR EAST

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DRAFT

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This program has been developed in accordance with the Far Eastern Leopard Conservation Strategy of the Russian Federation (1999), IUCN's Reintroduction Guidelines and the recommendations from two international conferences in Vladivostok on the conservation of Far Eastern leopards (Vyshin et al., 1996 and No author, 2001).

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1. INTRODUCTION

The leopard (*Panthera pardus*, Linnaeus 1758) has an extensive range stretching through much of the African continent and a large portion of Asia, reaching its easternmost point in Southwest Primorsky Krai in the Russian Far East. As many as 27 leopard subspecies have been described (Heptner and Sludsky, 1972) but presently, nine subspecies are recognized (Uphyrkina et al. 2001).

The Far Eastern, or Amur leopard (*Panthera pardus orientalis*) is one of the most endangered subspecies of large cats. Reduced to a fraction of its original population, the last remaining 25-34 individuals cling to existence in Southwest Primorsky Krai Russia. There are a few individuals remaining in Jilin and Heilongjiang Provinces of northeast China along the border with Russia and perhaps some in North Korea, although their status there is uncertain. Because the majority of Far Eastern leopards occur in Southwest Primorsky Krai, the Russian Federation has primary responsibility for the survival of this subspecies. Recognized as a genetically discrete subspecies (Uphyrkina et al. 2002, Miththapala et al. 1996), the Far Eastern leopard deserves protection as a unique genetic contribution to the species and to the region. Just as importantly, as a carnivore at the top of the trophic chain, the Far Eastern leopard acts as an indicator of ecosystem health and integrity. The leopard's importance, therefore, extends well beyond its status as one of many species threatened in a region with a unique and dwindling forest ecosystem.

This remaining population of Far Eastern leopards is threatened with a multitude of threats, including: 1) poaching of leopards and their prey; 2) habitat loss due to logging and forest fires; 3) construction and improvement of roads, a gas pipeline and other infrastructure in leopard habitat; 4) closing of deer farms that provided high density prey resources, especially important for females raising young; 5) a decline in the effectiveness of conservation law enforcement and the protected areas system in Southwest Primorye; and 6) the increasing potential for inbreeding depression and/or disease which can have quick and dramatic impacts on this single remaining population. (See Appendix I for more information on threats).

To safeguard against the potential loss of Far Eastern leopards in the wild, it is critical that a second population be established in the immediate future. The creation of a second population in no way lessens the need to protect the original population in Southwest Primorye, but does provide an opportunity to increase the numbers and genetic representation of this subspecies in the wild, and provides a margin of safety if one or some combination of the many threats in Southwest Primorye force that population to extinction.

The remaining population of Far Eastern leopards in Southwest Primorye has been cut-off from its former range in South Sikhote-Alin by a development corridor between Vladivostok and Ussurisk that includes a high way, railway tracks, agricultural fields and villages. The significance of this development corridor as a barrier to large carnivore movement is reflects in the fact that the tigers of Southwest Primorye are now genetically distinct from tigers in the Sikhote-Alin Mountains (Henry et al. 2009). It is likely that occasionally single dispersing leopards still cross into South Sikhote-Alin from the remaining population in Southwest Primorye. However, despite many reports of leopard tracks in the southern Sikhote-Alin (most unverified reports), there is no evidence of a stable, breeding population. All evidence suggests that the Far Eastern leopard cannot re-establish itself in the southern Sikhote-Alin without human assistance. Although substantial suitable habitat remains in Northeast China, at present inadequate protection and low prey densities prevent a substantial recovery in this part of its former range. Similarly, high human population densities and intense pressures on natural resources in DPR Korea will prevent recovery of the leopards in that country. A substantial increase in population numbers is also unlikely within the present range in Southwest Primorye as all suitable habitat appears to be occupied here (Murzin and Miquelle unpubl.).

In short; the critically endangered Far Eastern leopard population exists in an isolated habitat patch without the capacity to expand in its current range and without the possibility of dispersal leading to creation of a second population. This program therefore aims at facilitating a substantial recovery and increase in the number of individuals in the wild by means of reintroduction of Far Eastern leopards into their former range in the Southern Sikhote-Alin Mountains.

Captive Far Eastern leopards from zoo breeding programs will be selected to form an *in situ* founder breeding group in the reintroduction zone in south Sikhote-Alin. Breeding of captive adults, and release of their young, suitably trained leopards will take place in the Lazovsky Nature Reserve initially, with later releases planned in adjacent lands.

2. NEED FOR A REINTRODUCTION PROGRAM

At present there exists a single population of Far Eastern leopards in the Russian Far East. When a small, isolated population is the sole representation of a species or subspecies, there exist a host of environmental, genetic, disease, and stochastic challenges that can lead to extinction. To increase the probability of persistence, it is preferable to maintain large populations in unfragmented landscapes. When habitat fragmentation has already occurred, it is imperative that at least two (and preferably more) population exists so that a "reserve" exists in case extreme changes lead to extinction of the original population.

In the past 30 years localized extinctions of 2 isolated Far Eastern leopard populations have already occurred in Primorye (Pikunov and Korkishko 1985) (Figure 2). There have been similar localized extinctions in China and the Korean peninsula. Although the remaining population size of leopards in Southwest Primorye appears to have remained relatively stable over the past 30 years, it is highly possible that ongoing changes in the region, or in the population itself, could lead to extinction. Any increase in the existing threats to the population, including habitat loss, poaching, disease, or inbreeding, could be the critical factor leading to the demise of this population. While the first priority of all conservation actions directed at Far Eastern leopards must be the preservation of this original population in its existent habitat in Southwest Primorye, to safeguard against extinction in the wild it is imperative to create a second population.

There have been significant efforts over the past 15 years to improve the situation for the existing population via a wide variety of activities, including: 1) improved anti-poaching efforts; 2) intensive education programs directed at local citizens; 3) improved management of hunting leases where leopards occur; 4) improved management of fire, which destroys leopard habitat each year; 5) depredation compensation programs aimed at alleviating impact of leopards on deer farms; and, 6) improved management of protected areas in leopard habitat. While not all of these activities have proven as successful as desired, there has nonetheless been a major effort to improve conditions, without any apparent response (i.e., an increase in numbers) by the wild population. Analyses of habitat use by leopards (Murzin and Miquelle, unpubl. and see below) suggest that all available habitat in Southwest Primorye is presently occupied, and therefore it is unlikely that this population can increase substantially unless there is a dramatic increase in prey availability, or an increase in available habitat. Such changes may occur with improved management of ungulates, better fire management, and/or improved conditions in nearby China, but such activities will require years, if not decades, to effect the necessary changes. In the meantime, the threats to the existing population are growing, and steps must be taken to ensure the survival of a wild population, even if some catastrophe occurs in Southwest Primorye.

3. PROGRAM GOAL AND OBJECTIVES

Before delineating the goal and objectives of a reintroduction program, it is important to note that implementation of a reintroduction program in no way lessons the urgency or the need to conserve leopards in Southwest Primorye. The primary task in conserving Far Eastern leopards in the wild is to conserve the Southwest Primorye population, and any effort at reintroduction of a second population must not diminish efforts to conserve the original population. Methods used to achieve reintroduction goals must take into account the importance of the primary population.

The long-term (25-year) goal of this program is to restore a viable population of at least 50 Far Eastern leopards (including at least 15 reproducing females) in their historical range in southern Sikhote-Alin in Primorsky Krai.

The primary objectives needed to achieve the long-term goal are:

1. Identify optimal reintroduction areas and release sites.
2. Build a reintroduction center with breeding/release enclosures and creating the conditions required for breeding, adaptation and successful reintroduction of leopards.
3. Form a breeding group of captive leopards that will become the founders of the reintroduced wild population.
4. Take actions to maintain the quality of the leopard habitat including additional protection of prey species and leopards against poachers.
5. Breed leopards, preparing cubs for life in the wild and releasing them into the wild.
6. Implement a monitoring system and follow the movements of released individual leopards and the development of the reintroduced population as a whole.
7. Conduct an educational outreach program targeted at local citizens in order to increase their support for the program, and develop a compensation and conflict resolution program in order to ease tensions when leopards do cause damage.
8. Ensure international co-operation and support for the program.

4. CURRENT STATUS, NUMBERS, AND DISTRIBUTION OF FAR EASTERN LEOPARDS

With a total population of 25-34 individuals the Far Eastern leopard is one of the most - if not *the* most - endangered large cat subspecies on earth. The Far Eastern leopard is protected in all three range countries (i.e. The Russian Federation, DPR Korea and People's Republic of China). The leopard is included in Appendix I of the Convention on International Trade of Endangered Species (CITES) and the Far Eastern leopard is listed as *critically endangered* by the International Union for the Conservation of Nature (IUCN). In the Red Book of the Russian Federation (Danilov-Danilyan 2000) the Amur leopard is listed as Category I (i.e., among the rarest (sub)species, on the brink of extinction, inhabiting an extremely limited range, with the core population on the territory of the Russian Federation).

The Far Eastern leopard is the northernmost of all leopard subspecies. Its historic range extended throughout northeastern ("Manchurian") China, the southern part of Primorsky Krai in Russia and the Korean Peninsula (Figure 1). This range shrank dramatically during the 20th century, due primarily to habitat loss and hunting.

During the middle part of the 20th century (1940s to 1960s), Heptner and Sludsky (1972) described the northern boundary of permanent leopard distribution as beginning at the Sea of Japan at Dzhigit Bay at 44^{o} N latitude and then running south parallel to the coast for 15 to 30 km to Valentine Bay, and then turning westward and north encompassing the headwaters of the Ussuri River to the east bank of Lake Khanka (Figure 2). To the south and west of this line, leopards originally occurred most everywhere. The first reliable estimate of leopard numbers in Russia was made by Dmitry Pikunov and Vladimir Abramov in the winter of 1972-1973 (Abramov and Pikunov 1974). By this time, the population in Primorye had already fragmented into three isolated populations. In the southern Sikhote-Alin Mountains, leopards were most common along the coast, but there were only an estimated eight to 10 animals remaining. In the west, in Khankaisky and Pogranichny Raions southwest of Lake Khanka, there were five to six animals that moved back and forth between Russia and China. The third population, in southwestern Primorye, was estimated at 25 to 30 animals. Therefore, by 1973, there were an estimated 38 to 46 Far Eastern leopards remaining in Russia, many of which depended upon habitat on both sides of the Russian-Chinese border. A 1985 survey (Pikunov and Korkishko 1985) suggested that leopards had disappeared from the Khankaisky-Pogranichny region and from southern Sikhote-Alin. The leopard population in southwest Primorye remained approximately the same as in 1972 survey, 25 to 30 animals. A 1990-1991 winter survey suggested the population in southwest Primorye had remained stable at 30 to 36 animals, if migrants to and from China were included (Korkishko and Pikunov 1994). Since 1998, six surveys have been conducted in Southwest Primorye, with all results indicating 22-32 animals remaining.

There are an unknown number of leopards scattered throughout Jilin and Heilongjiang Provinces in China, probably with the majority of animals concentrated near the Russian border. There are indications that a slow recovery may have started in China as the result of improved conservation measures and the establishment of the Hunchun Reserve, which connects with Far Eastern leopard habitat in Southwest Primorye in Russia, but no reliable estimates of numbers exist.

The Far Eastern leopard probably went extinct in the wild in South Korea in the late 1960s. There may possibly still be individual leopards in the rugged northern region of North Korea near the Chinese border, but reliable information is lacking.
(For more information on the historic distribution of the Far Eastern leopard see Appendix II 1.)

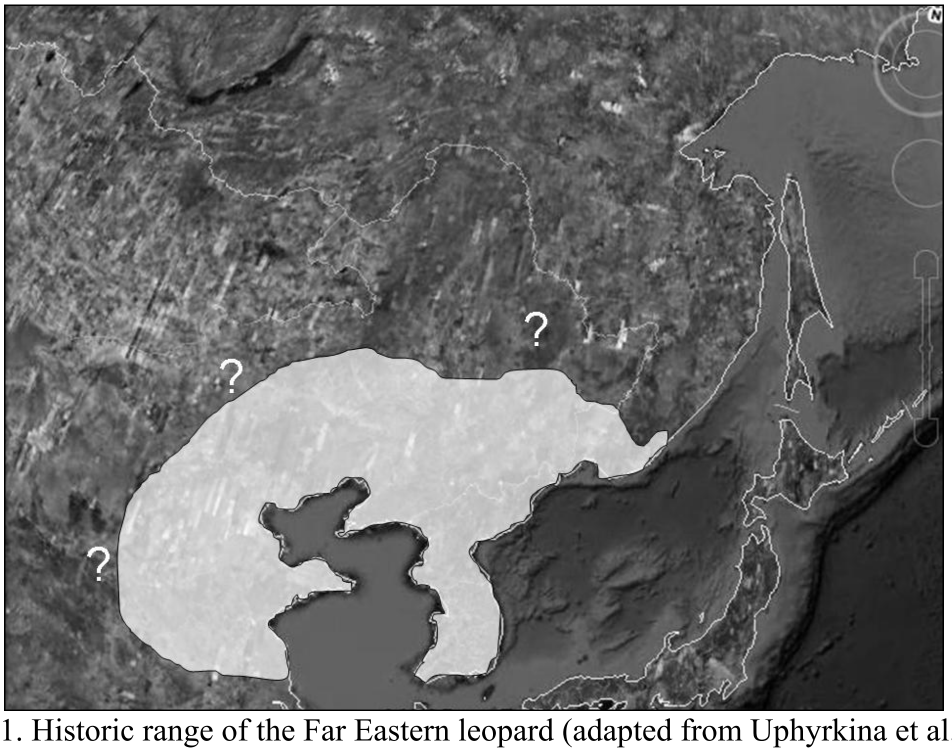


Figure 1. Historic range of the Far Eastern leopard (adapted from Uphyrkina et al. 2002)

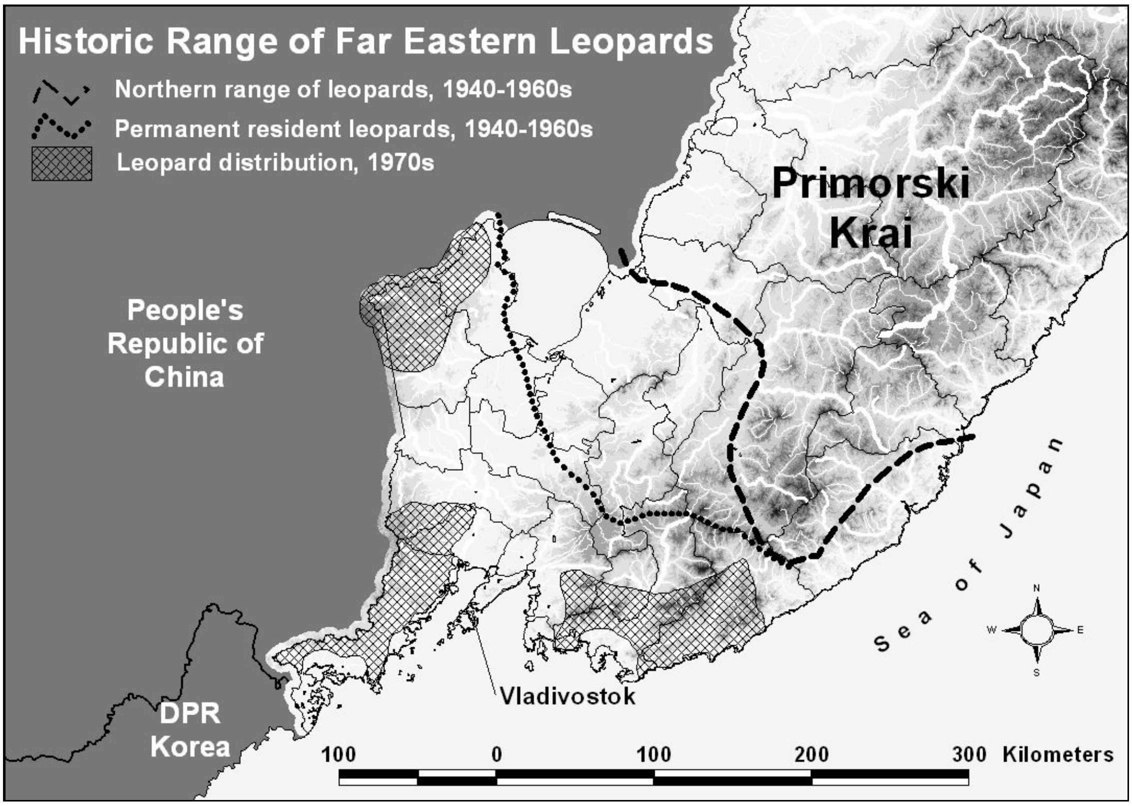


Figure 2. Historic range in the southern Russian Far East (based on Heptner and Sludsky 1972, Abramov and Pikunov, 1974)

5. CRITICAL NEEDS: BIOLOGY, ECOLOGY, AND GENETICS OF FAR EASTERN LEOPARDS

Information on natural history of the Far Eastern leopard is based primarily on two sources of information. Extensive studies during the winter months, when snow provides a tracking medium, have provided information through traditional snow-tracking techniques (Abramov and Pikunov 1974, Korkishko 1981, 1983, Pikunov and Korkishko 1992). More recently, more information has been gained from radio-tracking studies initiated on the Far Eastern leopard in Kedrovaya Pad Nature Reserve and Nezhinskoe Naval Hunting Lease, and from camera trapping.

5.1. APPEARANCE

The physical characteristics of the Far Eastern leopard are very distinctive. It has a light coat with long hairs of up to 7 cm on the tail and lower body parts. Far Eastern leopards are recognizable for their extremely large, thick-rimmed black rosettes or complete circular markings that cover their body. They have relatively long legs, probably an adaptation to snow conditions.

5.2. HABITAT

In Southwest Primorye the Far Eastern leopard inhabits mountainous, forested regions where there are sufficient numbers of roe deer (*Capreolus pygargus)*, sika deer (*Cervus nippon*), badger (*Meles leucurus*), Manchurian hare (*Caprolagus brachyurus*), and raccoon dog (*Nyctereutes procyonoides*). Leopards prefer broken topography with the dominant forest type being closed Korean pine (*Pinus koraiensis*)-black fir (*Abies holophylla*)-broad-leaved forests. This forest formation is found in the middle and upper basins stretching along the Russian-Chinese border, especially in the Borisovskoe Plateau region. Less preferred habitat used by leopards includes secondary growth broad-leaved forests of Mongolian and toothed oak (*Quercus mongolica* and *Q. denthalis*). Leopards seldom occur in woodland savannas except to visit deer farms. In winter the most commonly used habitat types include ridgetops and slopes with steep southern exposures where snow quickly melts. Preferred habitat is between 300-600 m above sea level.

One key factor limiting distribution of leopards is snow depth: leopards do not appear well adapted to deep snow. In winter leopards select the warmest habitats with the least snow cover, where the average long-term snow cover is 10-15 cm.

5.3. FOOD HABITS

The list of animals included in the diet of the Far Eastern leopard is extensive, including representatives of nearly all classes of vertebrates found within its habitat. The relative abundance of prey in the diet of southwest Primorye leopards has varied with different periods of observation, different regions, and with season. From 1961-1976 the diet of leopards was reported as: 66% roe deer, 9% musk deer, 8% wild boar (*Sus scrofa*), 6% sika deer, 4% hare, 3% badger, 3% raccoon dog, and 1% Manchurian elk (*Cervus elaphus*) (Abramov and Pikunov 1974). From 1970 to 1985 Korkishko (1986) reported the diet of leopards in Kedrovaya Pad Nature Reserve to be: 54% roe deer, 12% sika deer, 12% raccoon dog, 5% badger, 7% Manchurian hare, and small amounts (2.5%) of wild boar, musk deer, and pheasant. More recently, sika deer appear to represent the majority of the diet in Southwest Primorye (Aramilev and Belozor, unpubl. Data). Based on hair identification from 137 scats collected from the central current range of leopards Kerley and Borisenko (2007) reported ungulates as the most common food item (32% of food items) with sika deer the most common ungulate (55% of ungulates), roe deer uncommon (8%), but with 44% from unidentified ungulate. Other important food items included rabbit (16%), small rodents (14%) wild boar (8%), and birds (7%). Possibly because most scats were collected in winter and spring, badgers and raccoon dogs (which hibernate in winter but are often considered important prey items) represented only 3% of food items each.

Single adult leopards usually remain at kills of adult ungulates (roe and sika deer) for 5-7 days. Leopards are able to survive extended periods without food: there are recorded cases in Russia where the interval between kills was 10-12 days. Results of both snow tracking and radio-tracking suggest that on average an adult leopard requires one adult ungulate every 12-15 days. Under poor hunting conditions, or low densities of ungulates, the interval between kills of large prey can reach 20-25 days.

The relative contributions of roe deer and sika deer to the diet of leopards have changed as their relative abundance has changed in Southwest Primorye (with sika deer becoming the dominant cervid over the past 20 years) but all food habit studies indicate that medium-sized ungulates are the primary prey species for leopards, and therefore high densities of these species are key to survival and reproduction of leopard populations in Southwest Primorye, as well as in any reintroduced population.

5.4. SOCIAL ORGANIZATION AND HOME RANGE SIZE

Based on snow tracking, Pikunov and Korkishko (1992) documented that female leopards use home ranges that vary between 40 and 100 km^2 and that one male leopard used an area of approximately 300 km^2. Year-round home range sizes estimated with radio telemetry data (100% minimum convex polygon estimator) in Kedrovaya Pad are 33 and 62 km^2 for two adult females, and at least 280 km^2 for one adult male. In the Nezhinskoe area, two female leopards retained home ranges of 136 and 59 km^2 while two males retained home ranges of 212 and 155 km^2 (100% minimum convex polygon estimator) (Salmanova 2008). Both sources of information suggest that male leopards use larger areas than females.

Available Information on the land tenure system of Far Eastern leopards suggests clearly that females are. Adult resident females maintain an area exclusive of other adult females for herself and young. Resident male ranges overlap female territories, but it is not yet clear if adult males are clearly territorial. Radio tracking information as well as camera trapping results suggest that multiple males may overlap in one general area. Further radio telemetry studies are needed to elucidate this point.

The conclusion that Far Eastern female leopards maintain exclusive territories differs from results obtained from study of several African populations of leopards (Bailey 1993, Stander et al. 1997), and should be evaluated when more data is available.

5.5. Reproduction

The peak of breeding season for the Far Eastern leopard in the wild is not clearly defined, but may occur in the second half of the winter, though there is great variation in time of breeding. One to four kittens can be born, but usually, by the post-lactation period, a female is accompanied by no more than 1-2 kittens. Dens are often located in small caves with narrow openings, or occasionally in tree trunks. Kittens remain with the female for 1.5 to 2 years, and females therefore probably can breed once every two years.

5.6. Genetics and Taxonomic Status

Based on the most recent genetic analyses, nine subspecies of leopards are currently recognized (Uphyrkina et al. 2001) Genetic research based on samples from wild and captive Far Eastern leopards has confirmed this population forms a distinct subspecies (Uphyrkina et al. 2001). This research also confirmed that the wild population is highly inbred; a comparison with 22 samples from captive Far Eastern leopards showed that the captive population has actually retained a much higher level of genetic diversity than the wild population sample (See Appendix III for additional information).

6. RECOVERY ZONES AND RELEASE SITE

6.1. Selection of Recovery Zone

Of the four countries in which Far Eastern leopards formerly presided (Russia, China, North and South Korea), the opportunities for recovery of leopards is greatest in Russia, and secondly in China. With the creation of Hunchun Nature reserve adjacent to the existing leopard habitat in Southwest Primorye, there is an opportunity for recolonization of leopards to occur naturally in China. There, removal of snares, protection of forests, and greater human tolerance of leopards should allow naturally dispersing leopards from Southwest Primorye to colonize eastern Jilin and southern Heilongjiang Provinces. Such a process should not require human intervention if necessary conditions (high prey densities, no poaching of leopards) are provided. Such a process would represent an expansion of the existing population, a key component of successful conservation of leopards in the wild. But such a process will likely take decades to occur, and will depend upon the resolution of the Chinese government to conserve leopards.

Creation of a second population of Far Eastern leopards in their former range is most likely to succeed in Russia where two additional populations existed not long ago in western Primorye (Pogranichny Raion) and southern Sikhote-Alin (Abramov and Pikunov 1974). Both of these regions are at least partially isolated from Southwest Primorye. Of the two, southern Sikhote-Alin appears to provide a greater chance of successful reintroduction for the following reasons:

1) There is a vast unfragmented habitat into which leopards can expand in southern Sikhote-Alin (see below). Available habitat in Pogranichny Raion is very limited, and growth of a viable population would depend on expansion of the population into China, where conditions are more difficult to manage.
2) Available evidence suggests environmental conditions have improved over the past 30 years, with yearly average temperatures increasing and average snow depth decreasing. The coastal region of southern Sikhote-Alin is warmer than Pogranichny Raion.

3) Sika deer (presently the key prey species for leopards in Southwest Primorye) have become abundant over the past 30 years in the southern Sikhote-Alin, displacing red deer over much of southern Sikhote-Alin. Sika deer do not reach the same density in Pogranichny Raion.

4) A network of protected areas (Lazovsky Nature Reserve, Zov Taigi National Park, Vasilkovsky Zakaznik, and Ussuriisky Zapovednik) as well as well-managed hunting leases (Medved, Southern Valley) provide good conditions for both prey and leopards. No protected areas exist in Pogranichny raion.

To identify potential release sites, an analysis using the following steps was conducted (results and methods are detailed in Appendix XI):

1) A resource selection function (which is a mathematical function that is proportional to the probability of use of a resource unit, or geographical area) was developed from leopard survey data in Southwest Primorsky Krai to determine parameters that best predict suitable leopard habitat there.
2) The results were extrapolated to the entire southern half of Primorsky Krai to identify potential suitable leopard habitat.
3) Since size of potential habitat patches is a critical determinant of whether sufficiently large populations can exist in a landscape, we selected those patches of potentially suitable habitat that were 100 km^2 as potential “stepping stones” and patches of at least 500 km^2 as potential source sites where groups of 3-7 reproductive females may co-exist.
4) Least-cost analysis was conducted to determine which potentially suitable habitat patches were most connected to each other.
5) The values derived from the resource selection function and the numbers of leopards known to be there were used as a basis to extrapolate the potential number of animals that could exist in southern Sikhote-Alin potential habitat patches.

The analysis suggests that there are large patches of potentially suitable habitat in southern Sikhote-Alin, and relatively little suitable habitat in western Primorsky Krai (Pogranichny region) (Figure 3). There are 7 large patches (> 500 km^2) of potentially suitable habitat in southern Sikhote-Alin, with 13 additional smaller (>100 km^2) patches (Figure 4).

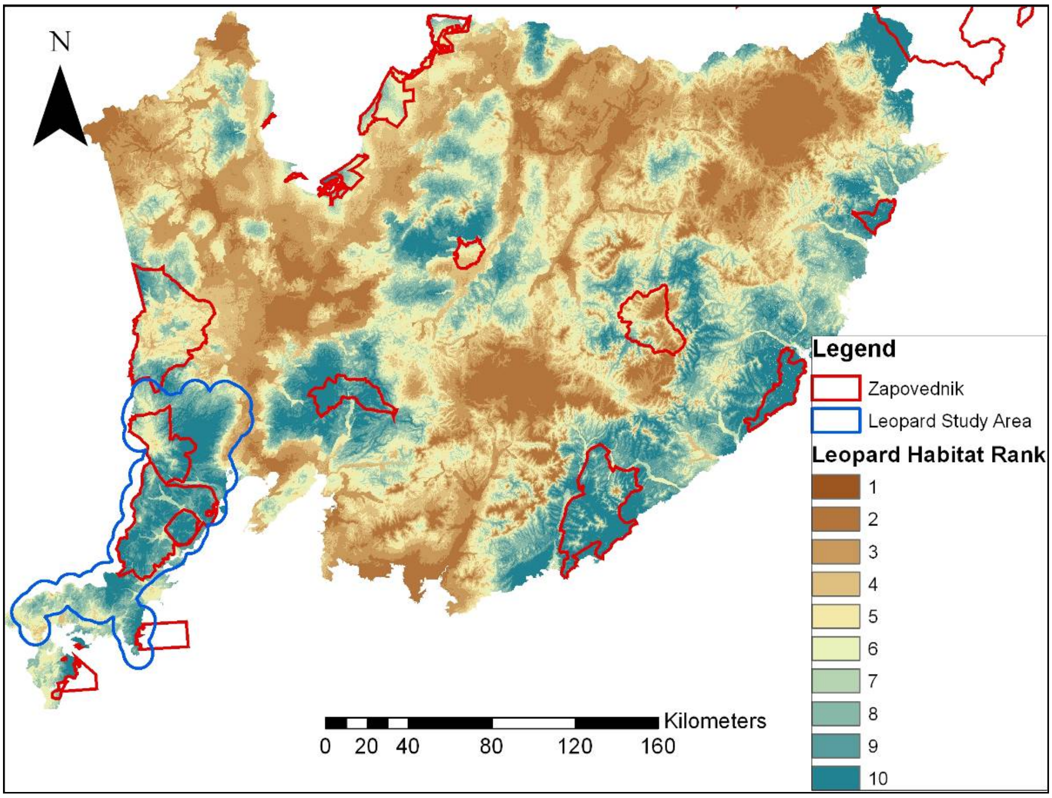


Figure 3. Potential Far Eastern leopard habitat based on the best model developed for Southwest Primorye. Predicted Far Eastern leopard habitat quality is shown in equal-area ranked categories from 1 (low quality=dark brown) to 10 (high quality=dark blue).

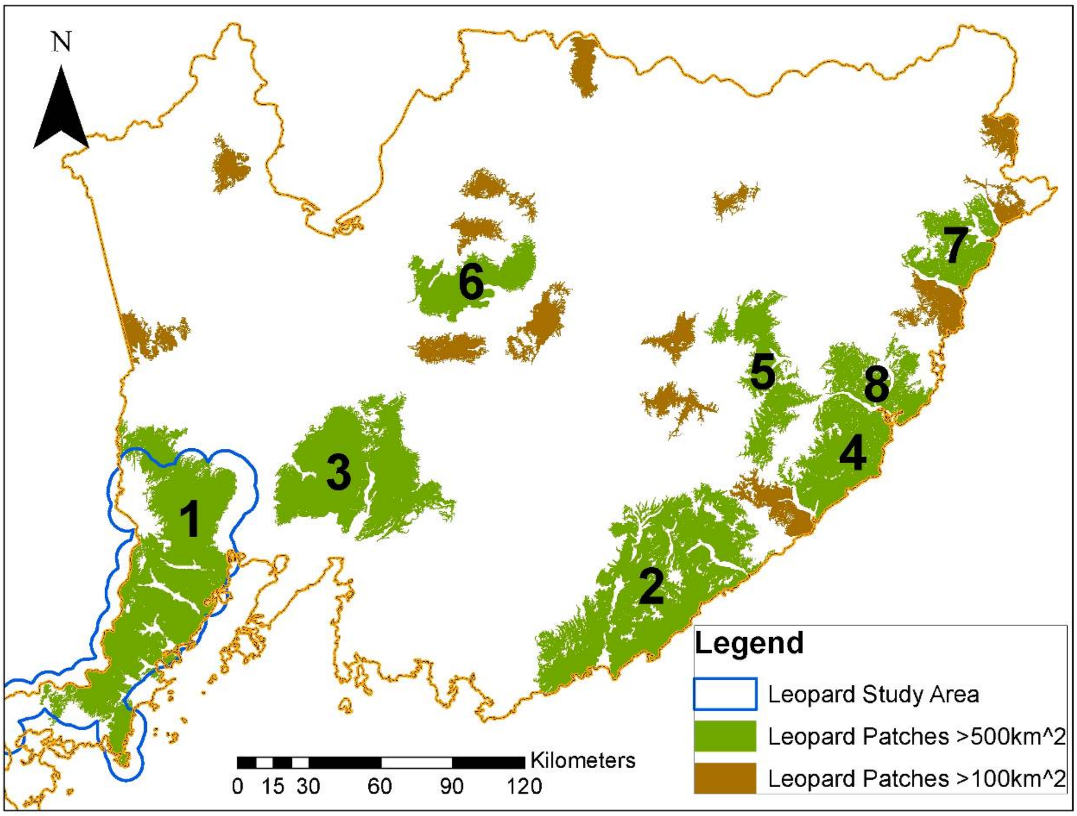


Figure 4. Predicted patches of Far Eastern leopard habitat obtained by applying a RSF model for Far Eastern leopards in Southwest Primorye to southern Sikhote-Alin. Patches >100 km^2 and >500 km^2 are shown to identify potential connectivity and population patches, respectively.

Least cost path analysis between potential leopard patches >100 km^2 revealed several discontinuous larger areas of potential leopard habitat (Figure 5). There exists a network of 5 suitable patches along the coastal areas that collectively comprise over 7000 km which represents the largest potential habitat complex for leopards in the Russian Far East (more than twice the size of Southwest Primorye. Ussuriisky Zapovednik and surrounding territories represent another suitable habitat patch, but total habitat available is not as great (2450 km^2) and the patch is isolated from other suitable habitat patches. Based on the least-cost analysis, connectivity between the coastal network and the inland patches (Ussurisk and Siniy Khrebet) is not high, but this must be considered in a relative context.

Using a mean adult leopard population size of 30.8 (SD 6.45) individuals for Southwest Primorye, we predicted a total of 116 (66.3-158.7) adult Far Eastern Leopards could occupy the 7 large patches in Southern Sikhote-Alin. If leopards can move amongst all 5 patches of the coastal complex (e.g., patches 2, 4, 5, 7, and 8), a total of 65 (38-89) Far Eastern leopards might be expected to occupy this large coastal region.

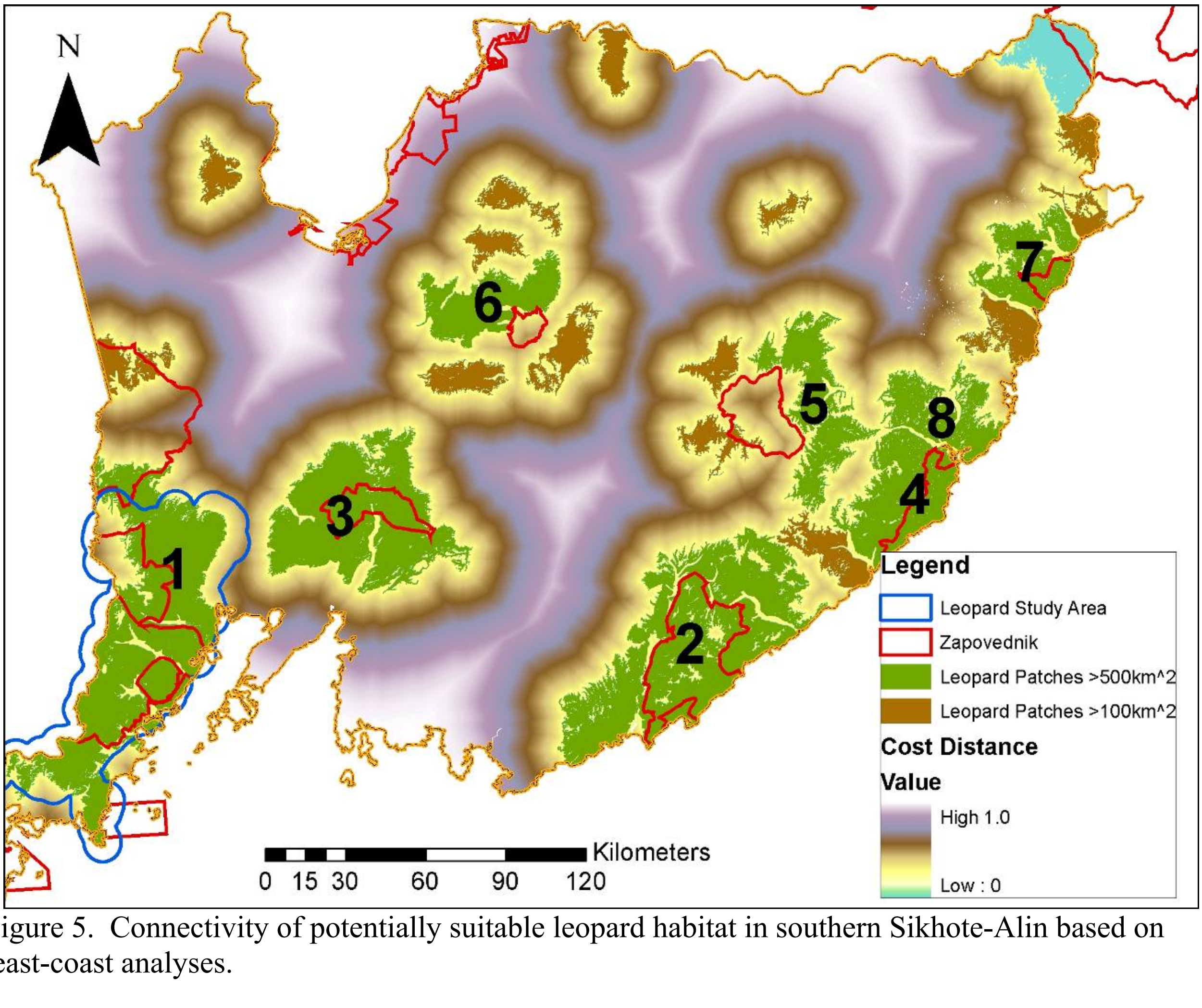


Figure 5. Connectivity of potentially suitable leopard habitat in southern Sikhote-Alin based on least-coast analyses.

Table 1. Habitat-based population estimates for the eight largest patches of potential leopard habitat in the Southern Sikhote-Alin based on Far Eastern leopard resource function model developed in Southwest Primorsky Krai

Patch #	Name	Area	Potential leopard population size		
			Average	Low	High
1a	SW Primorye – occupied[1]	3 501.5	30.8	17.7	42.3
1b	SW Primorye – northern unoccupied	200.5	2	1.1	2.7
2	Lazo	3 378.7	31.6	18.2	43.4
3	Ussriisk	2 450.6	20.9	12	28.8
4	Southern Valley East	1 209.7	14.9	8.5	20.4
5	Zov Tigra National Park	1 018.6	7.4	4.3	10.2
6	Siniy Khrebet	888.3	7.7	4.4	10.6
7	Kavalerovo	756	6.3	3.6	8.6
8	N. Olga	746.2	4.9	2.8	6.7
	Coastal network	7 109.2	65.1	37.4	89.3
	Total large patches Southern Sikhote-Alin	10 448	93.7	53.8	128.7

6.2 DESCRIPTION OF RECOVERY ZONE: SOUTHERN SIKHOTE-ALIN

6.2.1 Determination of Recovery Zone: size and location

Based on analyses above, the best area for reintroduction of Far Eastern leopards is a complex of suitable habitat patches along the coastal region of southern Primorsky Krai. Within this region, Lazovsky Zapovednik has the best protection, best infrastructure, and best conditions for release of leopards. Therefore, Lazovsky Zapovednik is considered the best site for first reintroduction of leopards, with expansion to occur into the primary recovery zone (see Figure 5). Total area of the primary recovery zone is 7,109 km^2. Additional habitat where leopards could expand is designated as the secondary recovery zone, which includes Ussuriisky Zapovednik and surrounding regions, including Shkotovsky and Ussuriisky Raions.

Further descriptions of the recovery zone focus on the initial reintroduction site (Lazovsky Zapovednik) and the designated primary recovery zone along the coastal regions of southern Sikhote-Alin.

6.2.2. Characteristics of Southern Sikhote-Alin

Southern Sikhote-Alin consists of mostly low, hilly terrains that rise to moderate size mountains. The most suitable regions for leopards will be the low rolling hills and moderate elevational habitats, especially close to the coast.

Vegetation communities most favorable for leopards are likely to be broadleaved and Korean pine-broadleaved forests. These types occur from seaside to 600-800 m above sea level. Above 700 m above sea level Korean pine-fir and spruce-fir forests are dominant. When fires occur within Korean pine-broadleaved forests, deciduous narrow-leaved forests (e.g. aspen, birch) regenerate.

The climate within the broadleaved and Korean pine-broadleaved zones of the southern Sikhote-Alin are monsoonal, with the majority of rains in the summer period and relatively little snow in winter. Effects of the continental climate are more common on the western (inland) side of the southern Sikhote-Alin Mountains.

Climate on the east slopes of the southern Sikhote-Alin Mountains is moderated by the proximity of the Pacific Ocean and is influenced by seasonal East Asian monsoonal winds. The comfortable period occurs for 45-80 days. Winter northwest winds bring cold continental winds from central Asia and Siberian and clear winters with little snow. Periodically there are weather patterns from the south that bring warming weather with temperatures of +3^{o} C to +4^{o} C. Summer weather patterns come mainly from the east and southeast, bring warm moist air from Japan and the Sea of Japan, ensuring a warm, wet summer.

The growing season (with temperatures above +5^{o} C) usually lasts from 15-20 April to 25-30 October, a period averaging 190 days with average temperatures at +13^{o} C. Stronger winds (from 20 m/s) are most common in the winter months. Dominant winds are from the northwest, with winds averaging 4-6 m/s. Fog and strong wet winds are common along the coast.
Average date of first snowfall is 20th November. Snow cover remains, on average until 7 April. Deepest snow cover reaches 70 cm, and a minimum is 2 cm, with average snow depth of 10-30 cm. Ground freezes to a depth of 98 cm on average, with a maximum of 150 cm. Average data that rivers freeze up is 19 November, and opening of rivers occurs, on average, on the 9th of April. First date of first frost is 28th September, and the last frost is, on average, May 22. Winter lasts, on average, 100-120 days.

The animals of southern Sikhote-Alin are largely represented by the Manchurian faunal complex. Most important for leopards are the key ungulates – sika deer, roe deer, and wild boar. Presently red deer do not occur within 30-50 km of the sea coast, or below 400-500 m above sea level. Additional prey species for leopards in southern Sikhote-Alin include badgers (*Meles meles*), raccoon dogs (*Nyctereutes procyonoides*), and Manchurian hare (*Caprolagus brachyurus*).

A positive factor for leopard reintroduction is the increase in numbers and distribution of sika deer in the southern Sikhote-Alin. Over the past 25 years sika deer have increased from a small population restricted to the coast to a large population that occurs 30-70 km from the coast across most habitats, and as far as 80-100 km inland along river bottoms (additional information in Appendix V).

6.2.3 Protected areas and hunting leases in recovery zone

Three protected areas exist within the coastal region of southern Sikhote-Alin. Lazovsky Zapovednik at 1210 km^2 is the lone Zapovednik and retains the most protected lands in the region. Other protected areas within the reintroduction zone include the newly created Zov Taigi National Park (821 km^2), and Vasilkovsky Wildlife Refuge (340 km^2). In the secondary recovery zone, Ussuriisky Zapovednik (404 km^2) is the lone protected area. Some the largest hunting leases in the primary recovery zone include Southern Valley, Medved, Bars, Barkhat, and Chin Sun.

6.2.4 Natural conditions and existing prey base for leopards

The natural conditions in the release area and primary recovery zone are favorable for leopards. Leopards can endure temperatures of up to -40 ˚C which are extremely rare within the southern Sikhote-Alin and especially within the core zone. Over the past 40 years weather records indicate that the average annual temperature has increased by 1 ˚C in the Sikhote-Alin, improving conditions for leopards. Snow depth is a limiting factor for leopards, with snow depths greater than 30-40 cm problematic if they exist for more than 7-10 days. However, average snow depth in Lazovsky Nature Reserve (below 700 m) is well below this threshold (Appendix IV).

Sufficient numbers of the main prey species - roe deer, sika deer, badger Manchurian hare, and raccoon dog are available in the reintroduction area and southern Sikhote-Alin as a whole (See Appendices IV and V). Numbers of sika deer, the primary prey for leopards in Southwest Primorye, have increased substantially since leopards became locally extinct in South Sikhote-Alin, and have largely replaced red deer. (See Appendix IV for more information on prey species).

6.2.5. Presence of other large predators

A number of other large predators occur in South Sikhote-Alin, namely Amur tigers, lynx, Himalayan black bears and brown bears. Except for tigers these predators do not pose a significant threat to leopards. Leopards and tiger compete for food and records of tigers killing leopards are not uncommon across Asia where they co-occur, including Russia. However, in Southwest Primorye, in very similar conditions as in South Sikhote-Alin, leopards have been able to survive, and indeed retain approximately the same density, despite the re-emergence of a tiger population that has reached relatively high densities over the past 10-15 years. The fact that leopards have not disappeared from Southwest Primorye provides strong evidence that, while leopards and tigers will always be competitors, leopards can co-exist with tigers in northern habitats if an adequate prey base exists.

6.2.6. Potential capacity for leopards

Extrapolating from habitat conditions the probability of leopards inhabiting a habitat patch (based on the RSF model – see Appendix XI) and leopard numbers in Southwest Primorye, it is estimated that 65 (37 to 89) leopards could exist in the coastal recovery zone. Extrapolations based on leopard densities derived from camera trapping (averaging approximately 1 individual/100 km^2) produces similar estimates (71 individuals). Additional suitable habitat inland (two inland patches including Ussurisk Zapovednik and Siniy Khrebet) could provide habitat for approximately 29 additional leopards, but whether these populations would be connected to the coastal meta-population is not clear.

6.3 BREEDING AND RELEASE SITE IN LAZOVSKY ZAPOVEDNIK

6.3.1. Lazovsky Zapovednik

The breeding and release of Far Eastern leopards will be carried out in Lazovsky Zapovednik where good protection of both leopards and prey can be provided. The reserve offers the most suitable locations for reintroduction as a result of its favorable landscape features (with hills with steep slopes and ridges very similar to the most favored habitat in Southwest Primorye), very high prey densities, remoteness from human settlements, excellent protection and relatively mild winter conditions. The reserve is located well within the former range of the Far Eastern leopard in southern Sikhote-Alin and represents the largest patch of suitable habitat identified by the RSF model (Figure 3).

The actual site for captive breeding and initial release will be in the Lazovsky State Reserve on the central section of the Kievka River (Figure 6). The Nature Reserve consists of a 1,210 km^2 strictly protected core zone and a 160 km^2 buffer zone.

Status and administrative control of the zapovednik. The Lazovsky Zapovednik was established in 1935 and consists of 120,998 ha that is a strictly protected core zone with a surrounding buffer zone of 15,978 ha. The reserve runs along the shore of the Sea of Japan and is located between 42°49′ and 43°′23 N latitude and 133°42 and 134°12 E longitude. The reserve falls within the administrative boundaries of Lazovsky Raion in Primorsky Krai. The head office is located in the village Lazo, the capital of the Lazovsky district.

General characteristics of the zapovednik. About 96% of the reserve is covered with forest. Average temperature during August, the hottest month of the year is +19.7 C, and the average temperature during January, the coldest month of the year, is –10.5 C. Average yearly rainfall is 712 mm.

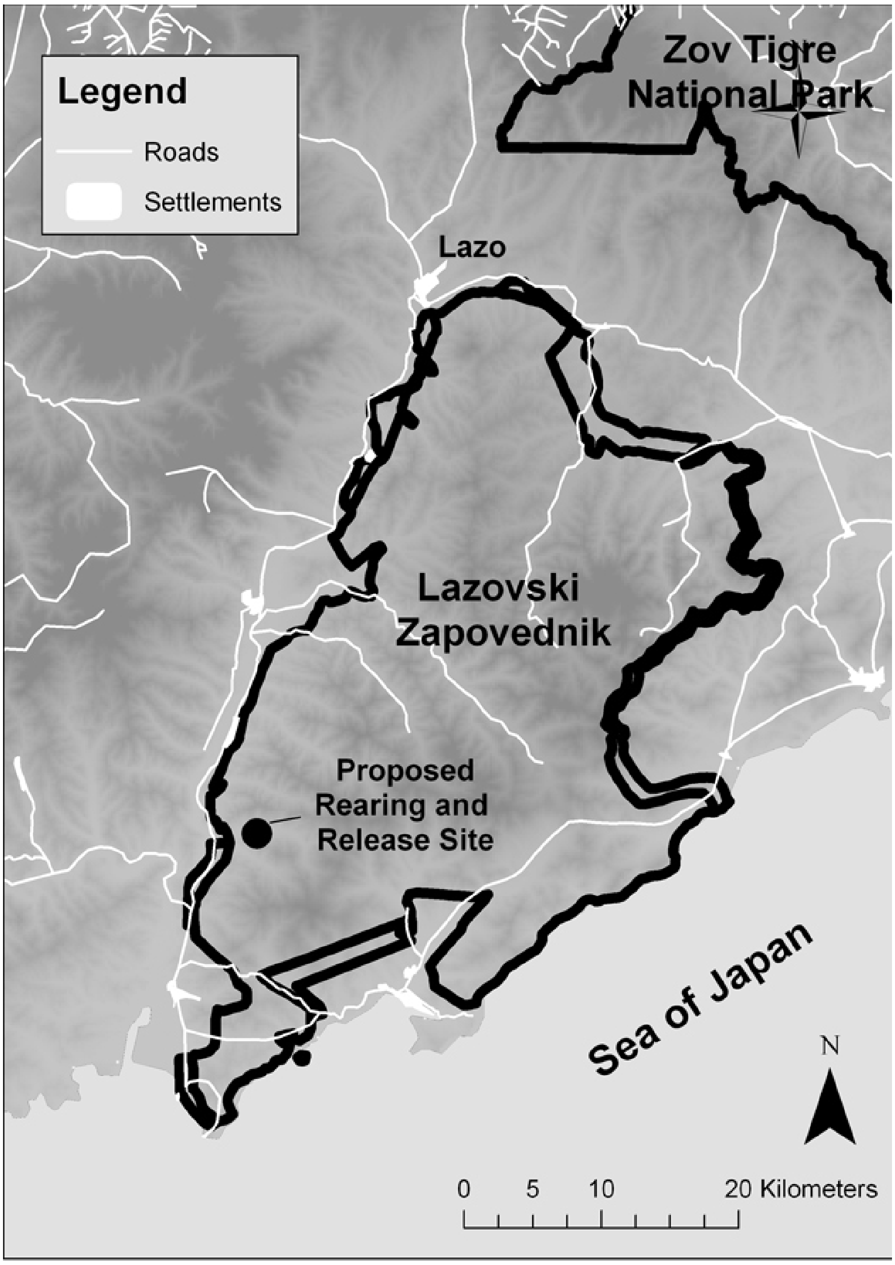


Figure 6. Location of the planned breeding center and release site in Lazovsky Zapovednik

Biodiversity. There exist approximately 14000 species of plants in Lazovsky Zapovednik, and 48 species of vertebrates, including 48 species of mammals, 286 species of birds, 8 amphibians, 7 snakes, 2 lizards, and 16 species of fish.

Status of Prey base. A variety of suitable prey species occurs in Lazovsky Zapovednik in high densities, including five species of ungulates: sika deer, red deer, roe deer, wild boar, musk deer and goral. The main prey of leopards in the recovery zone is likely to be sika deer and roe deer.

Roe deer are distributed primarily in the river valleys, in secondary oak forests, open fields and meadows. They are rarely found in the central part of the reserve, and therefore they number only approximately 300 individuals.

Sika deer occur throughout the Zapovednik, from the sea coast to the northernmost border. For the past 10 years numbers of this species have remained at high and stable numbers. An aerial survey in 2004 estimated 4150 sika deer, with three zones of density: the continental zone retained densities of 24.2$\pm$6.9 individuals/1000 ha; the central portion of the Kievka basin had densities of 69.9$\pm$13.4 individuals/1000 ha, and the coastal zone have the highest densities – 141.2+23.8 individuals/1000 ha.

Secondary prey of leopards includes raccoon dogs, badgers, and Manchurian hare. All three of these species are common in the Zapovednik, and in many areas they are considered abundant. For detailed information on prey numbers and densities, see Appendix IV.

6.3.2. Location for Breeding and Release Site

The recommended location in for rearing and release of leopards into the wild is located in the Lazovsky Zapovednik along the central portion of the Kievka River at Kamenny Creek (Ganzyuka Pad). This site has been selected as a rearing and reintroduction site based on the following criteria: similar habitat conditions as southwest Primorye, a favorable snow regime, high densities of sika deer, far from villages. The vegetation here is primary oak- broadleaved forest. In the upper reaches of the river Korean pine forests can be found. Along the right side (going downstream) steep slopes with southern expositions are common, with cliffs common in the upper reaches of the river. Sika deer density in this region is approximately 70 indivuals/1000 ha. Snow depth in this region averages 20-25 cm. two times less than the central portion of the Zapovednik.

Ten kilometers to the north of the proposed rearing and release site is situated the village of Svobodnoe (21 residents), and 12 km south is the village of Kievka (646 residents). The rearing and release site is 45 km from Lazo village along the main road to Preobrazhenie. At the border of the Zapovednik at the confluence of Kamenny Creek the field station "Zvezdochka" is situated. Up this valley along a forest road 5 km from the field station a small cabin can be found, which is the proposed site for a rearing and release facility. Only 100 m from the field station the power line is situated, paralleling the main road.

6.4 Reasons for Original Extinction of Leopards from Reintroduction Zone and Changes in the Environment since then

Despite the apparent disappearance of leopards by 1985 in southern Sikhote-Alin, there have been scattered but consistent reports of individuals up to the present (Mezentsev 1966, Kryukov 2007) in Ussuriisky, Mikhailovsky, Shkotovsky, Lazovsky, Chuguevsky, Kavalerovsky and Olginsky Raions of southern Primorsky Krai. Few of these reports are well documented, but at least some were made by experienced field observers, suggesting that at least some are reliable. One case, reported by Inspection Tiger, documented a leopard being hit by a car in the area of Tavrichanka (Nadezhdinsky Raion), suggesting that this animal likely dispersed across the Razdolnaya River from the existing population. This observation, plus the absence of consistent reports in a single location, suggest that most verifiable reports likely represent lone, dispersing individuals. There is no evidence of a stable population, or of any resident female leopards breeding in southern Sikhote-Alin since the 1972 survey.

Loss of the population in southern Sikhote-Alin including Lazovsky Zapovednik appears to be related to several factors that operated simultaneously, including:

1) A marginal prey base, where wild boar, red deer, and roe deer were the dominant ungulates (wild boar and red deer being generally too large for leopards to kill regularly). Sika deer, a primary prey of leopard in Southwest Primorye, occurred at that time only on the shores of the Sea of Japan in Olga and Moryak-Rybolov Bays.

2) Dramatic decrease in prey numbers associated with intensive hunting during World War II and afterwards severely decreased food availability for leopards;

3) Insufficient wildlife protection measures and enforcement, and a societal norm that sanctioned elimination of predators to increase prey numbers made leopards an easy target for hunters (since leopards, especially females, can be treed by dogs, hunting of them is easier than hunting of tigers) resulting in intensive persecution through the 1960s;

4) Leopards are not nearly as adaptable to deep snows as tigers, and a series of deep snow winters were probably debilitating for what was already a marginal population of leopards;

The circumstances for leopards have improved significantly in south Sikhote-Alin since the local population went extinct there in the 1970s. Over the past 40 years weather records indicate that the average annual temperature has increased by 1 ˚C in the Sikhote-Alin and average snow depths have decreased. Sika deer numbers have increased dramatically after they became fully protected in Lazovsky and Olginsky Raions in 1975. Since the leopard became extinct in this region sika deer have increased to such an extent that they have replaced other large ungulates (red deer and roe deer) as the dominant ungulate in the region, to such an extent that in certain areas they have severely denuded vegetation and caused erosion (Makovkin 1999). Sika deer are expanding their range north, both along the coast (now into central Terney Raion) and inland (into Dalnerechensky Raion, but are still largely absent from the central portions of the Sikhote-Alin Mountains (snow likely being a limiting factor).

(See Appendix V for more information on the natural conditions and prey populations of Southern Sikhote-Alin, and Appendix IV for more detailed information on Lazovsky Nature Reserve).

6.5 Design of Breeding and Release Facilities

The reintroduction facilities in the Lazovsky Nature Reserve will include storage facilities for food, equipment and other supplies, an electricity generator, staff housing, a leopard holding facility, a veterinary examination room, offices and meeting facilities, small enclosures for holding live prey (e.g. sika deer, roe deer, hares), as well as at least two large leopard breeding and release enclosures.

6.5.1. Breeding and release enclosure

The breeding and release enclosures (see Figure 7) will be located at least 200 m from the rest of the facilities. Breeding pairs from the captive population will not be released; only their cubs that have been prepared for release. Leopards destined for release will grow up without contact with humans. The leopard breeding enclosures will be situated within reach of transport, water supply and electrical power, but out of sight, sound and smell of the other buildings that are necessary for the operation of the center. All associated human activities to ensure that the animals in the enclosures cannot not smell, see or hear humans. Access to the facility will be via a single road, which will be guarded. Mineral breaks will be created to ensure that forest fires do not reach the center and its breeding enclosures.

Each enclosure will house a pair of leopards. The enclosures will have a length of 100 m. and will be in natural forest habitat with plant cover. Enclosures should take advantage of natural features in the landscape and, if at all possible, should include rocky areas, a natural stream for water, and natural shelter areas such as caves, overhangs or fallen/hollow trees. If natural shelter is not available in the area, it will be constructed from natural materials, i.e. trees and rocks. As few man-made items as possible will be present. Monitoring of the cats will be carried out via video cameras placed around the enclosures and linked to viewing screens in the staff areas.

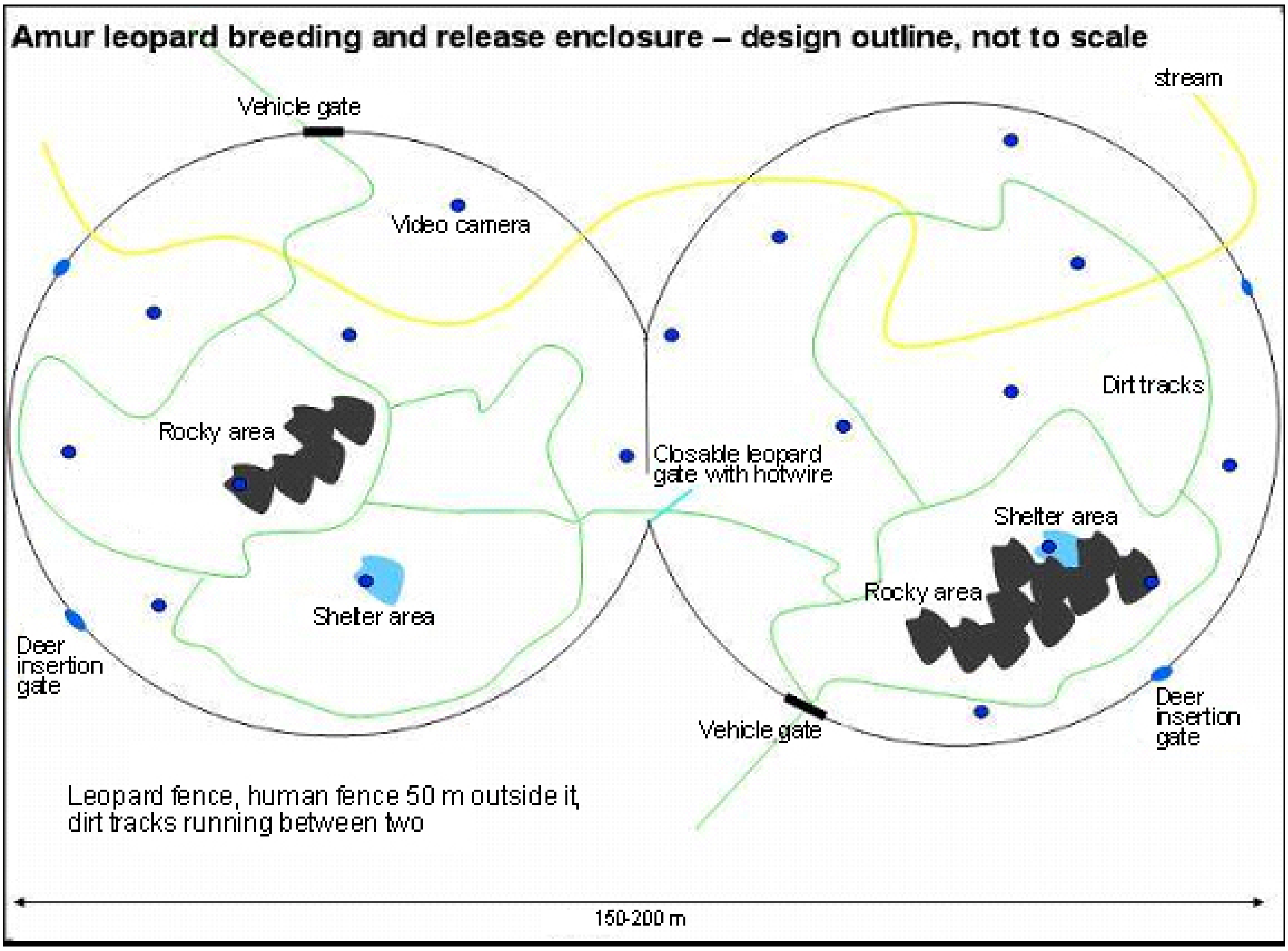


Figure 7. Basic design for breeding and rearing facility for reintroduction of leopards.

The enclosures will be shaped in a rough "figure-eight" with the central connection containing a leopard-proof closable gate. This design will allow leopards to be separated if necessary, or to be shut into one end to facilitate catching them or while live prey is released in the other end. The figure-eight shape also allows live prey to be chased around without being cornered, which will help captive leopards improve their hunting skills. Fences will be 5 m high with a 1.5 m overhang at the top. Use of hotwire (electrical current) on the fence will discourage escape. The enclosures will be designed and constructed so that associations with people are at an absolute minimum. Associations with humans will be designed to be negative reinforcements to condition leopards to avoid humans and human settlements. The enclosures will have food and water sites that can be accessed by keepers without contact with leopards and there will be the capacity to release live game into each pen without visual contact with humans. Observation blinds will allow keepers to watch the leopards without being seen themselves. The enclosures will have holding pens where leopards can be encouraged to enter if there is a need to contain animals (e.g., for examinations of animals or pens, or a need to isolate an animal). Large gates into each half of the enclosures, and dirt roads within, will permit vehicle access for captures of leopards and release of live prey.

Two breeding and release enclosures will be established at the reintroduction center, and at a later stage additional smaller enclosures can be set up at different locations within the reintroduction zone in southern Sikhote-Alin for final release of leopards.

6.6. Disease Risk Management

The Far Eastern leopard is potentially susceptible to a number of diseases carried by domestic cats, dogs or natural prey. An ongoing veterinary research program is identifying diseases in the wild as well as in captive Far Eastern leopard populations, natural prey and livestock. Disease risk assessments conducted in Lazovsky Raion indicate that risk of disease is low, with major threats coming from canine distemper. A vaccination program for domestic dogs in the vicinity of release sites will control this threat.

The veterinary research program will develop a disease risk management strategy that identifies disease threats, and provides guidelines to monitor and mitigate these in the existing wild Far Eastern leopard population, reintroduced leopards and other relevant wildlife and domestic species in southern Primorsky Krai. (See Appendix VI for more information on disease management).

Leopards from the zoo population that are selected for *in situ* breeding will receive vaccinations deemed necessary by veterinarians. The animals will be treated against skin parasites and will be subjected to multistage antihelminth treatment (until negative test results are achieved). Full medical screening of captive animals proposed for the reintroduction program will be conducted to ensure that they do not introduce new diseases or parasites into the reintroduction site. The EEP Far Eastern Leopard veterinarian will have primary responsibility for medical screening of all animals prior to movement to the breeding center and prior to release.

6.7. Potential for expansion of the Far Eastern Leopard population

From the Lazovsky Zapovednik leopards can easily disperse into the network of suitable habitat patches in coastal Sikhote-Alin, providing a total of over 7000 km^2 of suitable habitat for leopards. Although barriers are present, there exists continuous tracts of forests that could allow dispersal of leopards to the Ussurisk and Siniy Khrebet habitat patches to the west. Although these patches are smaller, and more fragmented, there does appear to be suitable habitat for leopards inland, although deep snow winters could greatly reduce leopard survival in these areas. Collectively, considering all large patches of suitable habitat in southern Sikhote-Alin, there exists the potential for over 90 leopards to survive in the southern Sikhote-Alin.

If connectivity between Southwest Primorye and southern Sikhote-Alin is retained and improved through an ecological corridor between Ussurisk and Vladivostok, then leopards would be able to disperse from the present population into the newly established population in Sikhote-Alin. Similarly, if corridors between China and Russia are maintained and improved, then a meta-population can be formed encompassing remaining habitat in Northeast China along the borders with Southwest Primorye and Pogranichny Raion, as well as DPR Korea. Such an interconnected network of protected areas and multiple-use lands could provide habitat for a much larger metapopulation with a much greater chance of persistence.

7. SOCIO-ECONOMIC ISSUES

A number of environmental and socio-economic conditions in Southern Sikhote-Alin have been taken into account in the development of this program.

7.1. PRESENCE OF LARGE PREDATORS AND THE INFLUENCE OF LEOPARDS ON THE DEVELOPMENT OF THE SOUTH SIKHOTE-ALIN ECOSYSTEM

Studies from different regions of the species' range, such as the Russian Far East (Korkishko 1986) and Central Asia (Lukarevsky 2001), have demonstrated that leopard predation does not deplete populations of their primary prey species. Existing studies have documented that wolf predation has a much greater impact on ungulate numbers than large felids (Miquelle et al. 2005, Kudaktin, 1975, 1978, 1980). Hence, the presence of leopards and tigers not only effectively limits distribution of wolves, but actually reduces the impact on ungulate numbers by large carnivores.

7.2. POSSIBLE CONFLICTS WITH THE HUMAN POPULATION

It is well documented that leopards regularly take dogs and other small domestic animals in their existing range in Southwest Primorye. Leopard dispersal following reintroduction in south Sikhote-Alin has therefore the potential of causing conflicts with humans (e.g. attacks on livestock and dogs) and dispersing leopards themselves run the risk of being killed by poachers. High densities of wild ungulates will reduce the desire of leopards to disperse long distances, and possible conflicts with local inhabitants will be defused by introducing a livestock predation compensation program for damages caused by leopards. A compensation scheme has been running in Southwest Primorye since 2000 and a similar program will be initiated that will cover the entire recovery zone in south Sikhote-Alin where both livestock killed by leopards and tigers will be compensated. Meetings will be held in town and village community centers in order to inform local hunters and other citizens of the compensation and reintroduction programs and ask for their support, including reporting encounters with leopards and poaching activities.

7.3 EDUCATION AND SOCIAL MONITORING

The attitudes and opinions of the local population concerning leopards and leopard reintroduction will be measured with social surveys and the issues that are of most concern to local people will be addressed by an education and public relations program.

(See Appendix VII for a more detailed description of the education program and social monitoring).

8. SOURCE POPULATION, BREEDING, CONDITIONING AND RELEASE

8.1. Source Population And Selection Of Leopards For Breeding

Leopards that will be used as a founder group for in situ breeding will be obtained from the Far Eastern leopard EEP (European Endangered Species Program) of the European Association of Zoos and Aquariums (EAZA) and from the Far Eastern leopard SSP (Species Survival Plan) of the North American Association of Zoos and Aquariums (AZA). The EEP for Far Eastern leopards includes zoos from the Russian Federation, other former Soviet countries and Europe, and is co-coordinated by representatives of the Moscow Zoo and the Zoological Society of London. It has been managed since 2000 with the aim of providing suitable leopards for *in situ* breeding and subsequent release of young leopards, and in July 2009 it comprised 114 leopards (67 males and 47 females) in 50 institutions. The Far Eastern leopard SSP comprised in late 2009, contains 48 animals in 30 zoos and has fewer animals genetically suitable for reintroduction stock than the EEP.

(See Appendix VIII for more information on the Far Eastern leopard EEP and provision of leopard for *in situ* breeding for reintroduction).

Selection of leopards for an in situ breeding (founder) group will be made as follows:

- All leopards that are used in the founder population will come from managed populations of the EEP (European Zoo Association) and SSP (North American Zoo Association).
- Leopards that fully represent the genetic spectrum of Far Eastern leopards will be selected in pairs to maximize genetic diversity of the founder population.
- Only pairs will be selected that have already proven to be successful breeders and that have produced healthy cubs.
- The inbreeding coefficient of selected leopards will not exceed 0.125.
- Each animal will be photographed on both sides of their bodies and a micro-chip will be implanted to allow later identification.
- Every animal will be screened for diseases, parasites, and health conditions according to EEP and SSP-approved protocols (Appendix IX)

8.2. Breeding

Breeding will occur in natural habitat enclosures in the area intended for the release. The founder breeding stock will be kept with the highest standards of nutrition and veterinary care Breeding animals will l be will be moved in and out of the facility over the lifetime of the reintroduction effort as needed. Only pairs that have successfully bred and reared in zoos will be used. Leopards from zoos should ideally arrive at the reintroduction center in spring to allow plenty of time for acclimatization before the onset of winter. They would initially go into a holding facility for a quarantine and acclimatization period before transfer to a breeding enclosure.

Monitoring via video cameras will help to establish pregnancy of a female leopard. When this occurs, the male will be moved from the breeding enclosure to a holding facility. The enclosure will include several suitable den sites for birthing and rearing a litter of cubs. The cubs will be captured, and given a veterinary check-up when they are approximately 8 weeks old. All cats in the breeding enclosures will be radio-collared at all times (except very young cubs), to assist in locating them within the enclosure and for recapture should there be an escape. Expandable collars allowing for growth will be placed on young cats.

Breeding leopards will remain in the center until they have contributed sufficient cubs and will then be returned to their home zoo and replaced by other cats of different genetic lines. It is expected that the process of establishing a stable population would take at least 10 years.

8.3. CONDITIONING

The young leopards that are born at the breeding and release center will be conditioned and prepared for life in the wild. Three necessary behaviors should be acquired prior to release: hunting and killing of live natural prey, avoidance of humans and avoidance of tigers. Leopards will be initially fed dead, unskinned natural prey in order to create a food association with natural prey species. Small live prey (for instance rabbits and piglets) will be provided to the young leopards when they are 5 months old in order to stimulate hunting behavior and gain experience in hunting techniques Live natural prey (sika deer or roe deer) will be introduced at a later stage (when the young leopards are approximately at 12 months old). We will consider using electro-collars for developing desired avoidance behavior. Young leopards can be introduced to human beings and a stuffed tiger and then given an electro shock in order to create a negative association which will hopefully result in avoidance behavior. Leopards that do not acquire the desired hunting skills and avoidance behavior - or manifest behavioral disorders - will be returned to a zoo.

8.4. RELEASE METHOD

The mother leopard will be removed as cubs reach dispersal age (when they are about 15 months old) at which time the young leopards will be captured, fitted with an adult-sized radio collar and given a final health check. When deemed appropriate, gates will then be opened, so that leopards can disperse on their own accord. The cats will be monitored as they disperse, but supplemental food will still be provided in the enclosure for at least two months after release, depending on whether leopards are still returning for food. Because release will occur at the developmental stage when young leopards normally disperse, we expect that the young leopards will gradually start spending more time outside the enclosure and will start exploring deeper and deeper into the surrounding forest. We anticipate that visits to the enclosure will become infrequent and likely end when the leopards are around 17-22 months old, at which time they will then no longer depend on food provided in the enclosure. If we have a choice of young leopards from different litters, we will release females somewhat earlier than males, because males tend to disperse further than females and the presence of a female may entice a dispersing male to set up territory in her vicinity. If births produce too many leopards of one sex, the surplus will be returned to suitable zoos within the breeding program. If possible, births should be planned such that dispersal can start in spring or early summer when prey availability in the wild is high. The dispersing leopards will then have sufficient time to adjust to life in the wild before winter starts.

Breeding pairs will need to produce a minimum of 20 cubs for release (8 males 12 females). The total number of releases will depend on survival and reproductive success of released individuals. Releases will take place during a period of 8 to 12 years and should not be discontinued before a population of at least 15 territorial mature female leopards has been established.

9. MONITORING OF RELEASED ANIMALS

A scientific team will be formed consisting of an experienced veterinarians and scientists with experience in monitoring radio-collared leopards and ecological research. The team will work on the basis of a predetermined research plan.

All released leopards will be fitted with radiocollars: some with GPS and some with standard VHF collars. GPS collars will provide detailed information on movements (but have a short lifespace -2 years - and a high failure rate) and will be placed more often on males (because these collars are heavier and more bulky) who are likely to travel greater distances. Most females will be fitted with standard VHF collars which have greater longevity (4-5 years) and allow monitoring of survival, reproduction, and mortality. The locations of territories established by newly released animals will be taken into account in determining future release sites.

Territory size, habitat selection, prey selection and relations to humans and tigers will be closely monitored. In winter snow tracking will be conducted in order to collect additional data on prey selection and other ecological aspects of the newly established leopards.

The radio collars make it possible to locate and capture leopards if they come into conflict with humans (e.g. livestock depredations), or to implement negative conditioning of these individuals. Problem animals that cannot be reconditioned will be captured and returned to captivity.

Leopards that die in the reintroduction center or in the wild will be recovered and undergo a necropsy by an experienced veterinary.

10. LAW ENFORCEMENT AND EDUCATION

Protection by law enforcement agencies will need to be intensified at both the Lazovsky Zapovednik and adjacent areas prior to releases. A mobile anti-poaching team of the Hunting Management Department of Primorsky Krai will be formed in order to provide additional protection and control of illegal hunting outside Lazovsky Zapovednik. Reserve staff will be responsible for leopards inside the reserve. These teams will co-ordinate activities on a daily basis with the scientific team that monitors radio-collared leopards.

An education and public relations program will be implemented in support of the reintroduction program. Education activities in schools, meetings with stakeholders and media activities will be organized and promotional materials such as brochures, calendars and posters will be printed and distributed in support of these education and public relations efforts. The (changes in) attitudes and opinions of local people concerning leopards and the reintroduction program will be measured with bi-annual social surveys. Education and public relations activities will start before the building of the reintroduction center commences.

11. EVALUATION

Overall effectiveness will be based on whether the population goal (50 individuals in the wild) is obtained. The rate at which the population grows will be dependent on survival rates and reproductive rates. Survival rates of at least 0.70 for adult and subadult females are needed for population growth.

Survival rates of leopards will also be an indicator of tolerance of local people to the presence of leopards. Surveys to measure public opinion will provide additional information as to local attitudes and acceptance of leopards into southern Sikhote-Alin (see Section 10).

Evaluation reports will be written every year to document progress and problems with implementation. A final report at the end of the 12-year period will describe results of the program as well as lessons learned that may be useful for future reintroductions of large felids.

12. RESOURCES AND FINANCIAL SUPPORT FOR THE PROGRAM

The organizations that participated in the development of the program have the required organizational and scientific resources and experience at their disposal for effective implementation. The Far Eastern leopard EEP is able to provide sufficient numbers of suitable leopards for *in situ* breeding.

The costs of the program will be substantial, between $US 5 and 10 million in total. Funds will be raised from international donors for program implementation, but financial commitment from the Russian government will also be required for success. Potential international donors include:

- Zoos that provide leopards for the founder population and other zoos involved in the Far Eastern leopard EEP.
- Conservation NGOs presently involved in Far Eastern leopard conservation including WWF, WCS, ZSL, Phoenix Fund and others who will be able to raise funds through their sponsors, including private sponsors, western governmental agencies and business firms.

A detailed program budget will be developed at a later stage.

13. SUMMARY OF PROGRAM STAGES AND ACTIVITIES

We expect the program to be implemented over a 12-year period. The following planning is based on an implementation period of 12 years.

Stage 1: Preparation (years 1 - 2)

- Discussion of draft reintroduction program with responsible authorities;
- Editing program based on feedback from authorities;
- Endorsement of Far Eastern leopard reintroduction program by appropriate government authorities and the IUCN Cat Specialist Group;
- First stage education and public relation program: survey of local attitudes and informing local citizens;
- Building a reintroduction center with at least two breeding/release enclosures;
- Selection of at least two breeding pairs of leopards from Far Eastern leopard EEP and SSP and transfer of these leopards to reintroduction center.

Stage 2: First breeding (year 3 - 4)

- Second education and public relations program: start of education activities;
- Improved protection within core recovery zone;
- Breeding by at least two leopard pairs;
- Rearing and conditioning of young leopards;

- First releases of young leopards.

Stage 3: Continued breeding and monitoring of released leopards (year 5 – 10)

- Monitoring released leopards;
- Continuation of education and protection programs;
- Breeding by 4-6 new leopard pairs;
- Continued rearing and conditioning of young leopards;
- Building breed and release enclosures away from areas where leopards have already established home ranges.

Stage 4: Releases are discontinued – continued monitoring (year 11 – 12)

- Breeding and releases are discontinued
- Monitoring, additional protection and education are continued
- Program evaluation and publication of evaluation report (year 12)

14. PARTICIPANTS

Ministry of Natural Resources of the Russian Federation: oversight of program; provides permits, coordinates and provides control over program procedures.

Federal Supervisory Agency for Resource Management, Rosprirodnadzor, Primorsky Krai: provides control over program procedures.

Lazovsky Zapovednik (Nature Reserve): provides protection of released leopards and prey species in the reserve, leads construction and management of the reintroduction center, participates in the implementation of the education program and scientific monitoring.

Administration of Primorsky Krai: provides permitting, coordinates and provides control over program procedures as well as protection of leopards and prey species outside federal protected areas.

Institute of Biology and Soils of the Russian Academy of Science, Far Eastern Branch, Vladivostok: provides scientific expertise including design and implementation of the monitoring program.

European Zoo and Aquarium Association / Far Eastern leopard EEP: oversees management of the captive Far Eastern leopard population in Europe and Russia and provides leopards for the founder group.

Wildlife Vets International. Is the veterinary consultant for the Far Eastern leopard EEP and provides veterinary support for the reintroduction.

American Zoo Association (AZA) oversees management of the captive Far Eastern leopard population in North America via a Species Survival Plan (SSP) provides leopards for the founder group.

World Wide Fund for Nature (WWF): provides management capacity, financial and scientific support.

Wildlife Conservation Society (WCS): provides financial and management as well as scientific support and will assist in monitoring of radio-collared leopards.

Zoological Society of London (ZSL) and Moscow Zoo: co-ordinate the selection of leopards from the Far Eastern leopard EEP and SSP.

Phoenix Fund: assists in the planning and implementation of education and media activities, as well as in the protection of leopards and prey, and provision of financial support.

Zov Taigi: assists in the planning and implementation of education and media activities, including production of videos, articles and other (multi) media activities.

15. LITERATURE CITED

Abramov, V. K., and D. G. Pikunov. 1974. The leopard in Far Eastern USSR and its protection. Biol. MOEP. Dept. Biol. 79:5-15. (in Russian)

Aramilev, V. V., P. Fomenko, and D. G. Miquelle. 1999. A 1998 survey of leopards. Zov Taiga: 4:6-11 (in Russian).

Aramilev, V.V. and P.V. Fomenko. 2000. Simultaneous survey of Far Eastern leopards and Amur tigers in Southwest Primorsky Krai, winter 2000. In "A Survey of Far Eastern Leopards and Amur Tigers in Southwest Primorye Krai, in 2000". Final report.

Augustine, J., D. G. Miquelle, and V. G. Korkishko, 1996. Preliminary Results of the Far Eastern Leopard Ecology Project: Implications for Conservation and Management. Zov Taigi.

Bailey, T.N. 1993. The African leopard. Columbia University Press, New York.

Baogang, S., D. G. Miquelle, Y. Xiaochen, E. Zhang, S. Haiyai. G. Goshen, D. G. Pikunov, Y. M. Dunishenko, and I. G. Nikolaev, and L. Daming. 1999. 1999 Survey of Amur Tigers and Far Eastern Leopards in Eastern Heilongjiang Province, China, and Recommendations for their Conservation. A final report to The Wildlife Conservation Society. 67pp.

Belden, R. C. and J.W. McCown. 1996. Florida panther reintroduction feasibility study. Fla. Game and Fresh Water Fish Comm., Bur. Wildl. Res. Final Rep. 70 pp.

Boyce, M. S. 2006. Scale for Resource Selection Functions. Diversity and Distributions 12:269-276.

Boyce, M. S. and J. S. Waller. 2003. Grizzly Bears for the Bitterroot: Predicting Potential Abundance and Distribution. Wildlife Society Bulletin 31:670-683.

Boyce, M. S. and L. L. McDonald. 1999. Relating populations to habitats using resource selection functions. Trends in ecology and evolution 14:268-272.

Bromley GF and Kucherenko (1983). Ungulates of the southern Far East USSR. Nauka, Moscow. (in Russian)

Budischev A.F. Description of forests of part of Primorsky region. Notes of Siberian department of Imperial Geographic Society. Irkutsk, 1867. Vol. 9-10. Pp. 167-218 (in Russian)

Chetkiewicz, C. L. B. and M. S. Boyce (2009). "Use of resource selection functions to identify conservation corridors." Journal of Applied Ecology 46(5): 1036-1047.

Chetkiewicz, C. L. B., C. C. S. Clair, and M. S. Boyce. 2006. Corridors for Conservation: Integrating Pattern and Process. Annual Review of Ecology Evolution and Systematics 37:317-342.

Ciarniello, L. M., N. S. Boyce, D. C. Heard, and D. R. Seip. 2007. Components of Grizzly Bear Habitat Selection: Density, Habitats, Roads, and Mortality Risk. Journal of Wildlife Management 71:1446-1457.

Danilov-Danilyan, V.I. 2000. Red Book of the Russian Federation. Astrel Publishing, Moscow.

Ermoshin V.V. Aramilev V.V. Main principles of mapping of ungulates and carnivores habitats based on satellite topography data. Proceedings of XII Workshop of geographers of Siberia and the Far East. October 5-7, 2004, Vladivostok, Pacific Institute of Geography FEB RAS. Vladivostok: Izd-vo "K and partners", 2004. Pp. 157-159 (in Russian)

Goodrich, J.M., K. S. Quigley, D. G. Miquelle, E. N. Smirnov, L. L. Kerley, B. Schleyer, H. B. Quigley, M. G. Hornocker, and D. Armstrong. 2005. Chapter 8. Blood chemistry and infectious diseases of Amur tigers. Pp. 43-49 in Miquelle, D.G., E.N. Smirnov, and J.M. Goodrich (eds.). Tigers in Sikhote-Alin Zapovednik: Ecology and Conservation. PSP, Vladivostok (in Russian).

Heinsch, F. A., M. A. Reeves, P. Votava, K. Sinkyu, C. Milesi, M. Zhao, J. Glassy, W. Jolly, R. Loehman, C. Bowker, J. Kimball, R. Nemani, and S. W. Running. 2003. User's Guide: GPP and NPP (MOD17A2/A3) Products, NASA MODIS Land Algorithm. Numerical Terradynamics Simulation Group, College of Forestry and Conservation, University of Montana.

Henry, P., D. Miquelle, T. Sugimoto, D.R. McCullough, A. Caccone & M. A. Russello. 2009. *In situ* population structure and *ex situ* representation of the endangered Amur tiger. Molecular Ecology 18:3173-3184

Heptner, V.G., and A.A. Sludsky. 1972. Mammals of the Soviet Union. Vol. 2. Carnivores (Hyenas and Cats). Vysshaya Shkola, Moscow. (in Russian)

Hosmer, D. W. and S. Lemeshow, editors. 2000. Applied Logistic Regression. John Wiley and Sons, New York.

Huete, A., K. Didan, T. Miura, E. P. Rodriguez, X. Gao, and L. G. Ferreira. 2002. Overview of the Radiometric and Biophysical Performance of the Modis Vegetation Indices. Remote Sensing of Environment 83:195-213.

IUCN/SSC Re-introduction Specialists Group. 1998. Guidelines for Re-introductions. Gland, Switzerland and Cambridge, UK. 20 pp.

Johnson, C. J. and D. R. Seip. 2008. Relationship Between Resource Selection, Distribution, and Abundance: a Test With Implications to Theory and Conservation. Population Ecology 50:145-157.

Johnson, C. J. and M. P. Gillingham. 2008. Sensitivity of Species-Distribution Models to Error, Bias, and Model Design: an Application to Resource Selection Functions for Woodland Caribou. Ecological Modelling 213:143-155.

Johnson, D. H. 1980. The comparison of usage and availability measures for evaluating resource preference. Ecology 61:65-71.

Jordan, D. B. 1994. Identification and evaluation of candidate Florida panther population reestablishment sites. Pages 106-153 in D.B. Jordan, ed., Proc. of the Florida Panther Conference. Ft Myers, Florida.

Kerley, L.L. and M.I Borisenko. 2007. Using Scat Detection Dogs to Collect Amur leopard and tiger scats for comparative analysis. A final report to the Wildlife Conservation Society, June 2007

Khramtsov V.S., Khokhryakov S.A. Data on leopard abundance in southern spurs of Sikhote-Alin Mountains. Ecology. 1991. # 5. Pp. 85-87. (in Russian)

Klein, A. G., D. K. Hall, and G. A. Riggs. 1998. Improving Snow Cover Mapping in Forests Through the Use of a Canopy Reflectance Model. Hydrological Processes 12:1723-1744.

Kolesnikov B.P. Geobotanical zoning of the Far East and distribution patterns of vegetation resources. Issues of geography of the Far East. 1963. Vol. 6. Pp. 158-182. (in Russian)

Kolesnikov B.P. Korean pine forests of the Far East. Moscow: Nauka, 1956. 262 p. (in Russian)

Kolesnikov B.P. Vegetation of Tachinzhan Ridge (Southern Sikhote-Alin, Sudzukhinsky branch of Sikhote-Alin State Reserve). Vestnik BMA AN SSSR. 1937. # 24. Pp. 97-104. (in Russian)

Kolesnikov B.P. Vegetation. The Far East: Physiographic characteristics. Moscow: Nauka, 1961. Pp. 183-298. (in Russian)

Korkishko, V. 1996. Captured leopard shot by poacher in Russia. Cat News 25:7-8.

Korkishko, V. G. and D. G. Pikunov. 1994. The population number of the Far East leopard in 1991 in Russia. Unpubl. report to the Species Survival Commission, IUCN 19th General Assembly, Buenos Aires, Argentina.

Kryukov V.H. Encounters with Far Eastern leopards in Lazovsky (Sudzukhinsky) State Nature Reserve 1936–2006 гг. VIII Far Eastern Conference on Reserve management and studies. Conference Proceedings. Blagoveschensk: Izd-vo BGPU, 2007. Pp. 201-205. (in Russian)

Kucherenko, S.P. 1993. The price of tiger conservation. Okhota I okhotnichie khozyaistvo 2:16-19. (in Russian)

Kudaktin A.N. A ratio of ungulates to wolf abundance in Caucasian Reserve// Ungulates of fauna of USSR. Moscow: Nauka, 1975. Pp. 199-200. (in Russian)

Kudaktin A.N. Selectivity of wolf preying on ungulates in Caucasian Reserve. Bull. MOEP. Dept. Biol. 1978. Vol. 33, # 3. Pp. 19-28 (in Russian)

Kudaktin A.N. Wolf behaviour in protected area ecosystem. *In*: Wolf behaviour. Moscow, 1980. (in Russian)

Kurentsov A.I. 1965. Zoogeography of Priamurye. Moscow-Leningrad: Nauka. 154 p. (in Russian)
Laptev A.A., Makovkin L.I., Medvedev V.N., Salkina G.P., Sundukov Yu. N. Cadastre of terrestrial vertebrates of Lazovsky Reserve. Vladivostok: Dalnauka. 1995. 52 p. (in Russian)
Lukarevsky V.S. Leopard, striped hyena and wolf in Turkmenistan. M.: 2001. 128 p. (in Russian)
Makovkin L.I. 1999. The sika deer of Lazovsky Reserve and surrounding areas of the Russian Far East. 127 pp. (in Russian)
Manly, B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald, and W. P. Erickson, editors. 2002. Resource selection by animals: statistical analysis and design for field studies. Second Edition. Kluwer, Boston, USA.
Matyushkin, E. N. , D. G. Pikunov, Y. M. Dunishenko, D. G. Miquelle, I. G. Nikolaev, E. N. Smirnov, G. P. Salkina, V. K. Abramov, B. I. Bazylnikov, V. G. Yudin, and V. G. Korkishko. 1999. Distribution and numbers of Amur tigers in the Russian Far East in the mid-1990's. Pages 242-271 in A. A. Aristova (ed.) Rare mammal species of Russia and neighboring territories. Russian Academy of Sciences Theriological Society, Moscow (in Russian).
Menard, S., editor. 2002. Applied logistic regression. Second Edition. Sage Publications, London.
Mezentsev D.N. 1997. Leopard in Lazovsky Raion. Zov Taigi, # 32-33, pp. 18-24.
Miquelle, D. G., P. A. Stevens, E. N. Smirnov, J. M. Goodrich, O. J. Zaumyslova, and A. E. Myslenkov. 2005. Competitive exclusion, functional redundancy, and conservation implications: tigers and wolves in the Russian Far East. Pages 179-207 in Ray, J., J. Berger, K. Redford, & Steneck (eds.). Large Carnivores and the Conservation of Biodiversity. Island Press.
Miquelle, D.G. A. Kostyria, D.G. Pikunov, V.V. Aramilev, A. Skorodelov, and D. McCullough. 2003. New Surveys Confirm Amur/Far Eastern Leopard on verge of extinction. Cat News 38:3.
Miquelle, D.G., V. V. Aramilev, D. G. Pikunov, and P. Fomenko. 1998. 1998 Far Eastern leopard census in Russia and status of the subspecies across the Far East. Cat News
Miththapala, S., J. Seidensticker, and S. J. O'Brien. 1996. Phylogeographic subspecies recognition in leopards (*Panthera pardus*): molecular genetic variation. Conservation Biology 10:1115-1132.
Mladenoff, D. J., T. A. Sickley, and A. P. Wydeven. 1999. Predicting Gray Wolf Landscape Recolonization: Logistic Regression Models Vs. New Field Data. Ecological Applications 9:37-44.
No Author. 2001. Recommendations of the Workshop for Conservation of the Far Eastern Leopard in the Wild, May 11-14th, 2001, In Vladivostok, Russia
Nowell, K., and P. Jackson. 1996. Status and Conservation Action Plan: Wild Cats. IUCN/SSC Cat Specialists Group. IUCN Gland, Switzerland.
O'Brien, S. J. and J. F. Evermann. 1988. Interactive influence of infectious disease and genetic diversity in natural populations. Trends in Ecology and Evolution 3:254-259.
O'Brien S.J., Roelke M.E., Yuhki N., Richards K.W., Johnson W.F., Franklin W.L., Anderson A.E., Bass O.L., Jr., Belden R.C., and Martenson J.S. 1990. Genetic introgression within the Florida panther *Felis concolor coryi*. National Geographic Research. 6; 485-494.
O'Brien, S.J. D.E. Wildt, D. Goldman, C. R. Merril, and M.L Bush. 1983. The cheetah is depauperate in genetic variation. Science 221 (4609), 459.
Pikunov D.G., I.V. Seryodkin, V.V. Aramilev, I.G. Nikolaev, A.A. Murzin. Large carnivores and ungulates of Southwest Primorsky Krai. Vladivostok: Dalnauka, 2009. 96 p. (in Russian)
Pikunov, D. G. and V. G. Korkishko 1985. Present distribution and numbers of leopards (*Panthera pardus*) in the Far East USSR. Zool. Jour. 64(6):897-905. (in Russian).
Pikunov, D. G., and K. G. Korkishko. 1992. The Far Eastern leopard. Nauka, Moscow. 192pp. (in Russian).
Pikunov, D. G., D. G. Miquelle, V. K. Abramov, I. G. Nikolaev, I. V. Seryodkin, A. A. Murzin, and V. G. Korkishko. 2003. Results of population surveys of leopards (*Panthera pardus*

orientalis) and tigers (*Panthera tigris altaica*) in Southwest Primorsky Krai, Russian Far East. Final Report.

Pikunov, D. G., V. K. Abramov, V. G. Korkishko, I. G. Nikolaev, A. I. Belov. 2000. "Sweep" Survey Of Far Eastern Leopards And Amur Tigers. In "A Survey of Far Eastern Leopards and Amur Tigers in Southwest Primorye Krai, in 2000". Final report.

Pikunov, D.G. 1981. The scope of predation of the Amur tiger. Redkie i ischezaiuschie zhivotnye sushi Dalnego Vostoka SSSR. Materialy konferentsii. Vladivostok: DVNC AN DSSSR. Pp. 71-75. (in Russian)

Pikunov, D.G., V.G. Korkishko, and V.I. Schetinin. 1989. On the probability of leopards remaining in on the eastern macroslope of the Sikhote-Alin Mountains. Theriological studies in the southern Far East. Vladivostok: DVO AN SSSR. Pl. 125-131 (in Russian)

Pikunov, D.G., V.V. Aramilev, P.V. Fomenko, D.G. Miquelle, V.K. Abramov, V.G. Korkishko, I.G. Nikolaev. 1997. Leopard numbers and its habitat structure in the Russian Far East. 1997. Final report.

Poddubnaya N. Ya. Trophic chains of carnivores and small mammals in the forests of the eastern slopes of Southern Sikhote-Alin Mountains. *In*: Dynamics of rodent abundance in the Far East of the USSR and their role in natural communities and agrocenosis. Brief outline of a report. Vladivostok. 1982. Pp.33-34. (in Russian)

Roelke, M. E., J. S. Martenson, and S. J. O'Brien. 1993. The consequences of demographic reduction and genetic depletion in the endangered Florida panther. Curr. Biol. 3:340-350.

Roelke, M.E. 1990. Florida panther biomedical investigation. Final Performance Report 7506. Florida Game and Fresh Water Fish Commission, Tallahassee. 199 pp.

Roelke-Parker, M.E., L. Munson, C. Packer, R. Kock, S. Cleaveland, M. Carpenter, S.J. O'Brien, A. Pospischil, R. Hofmann-Lehmann, H. Lutz, G. L. M. Mwamengele, M. N. Mgasa, B. A. Summers, and M.J.G. Apel. 1996. A canine distemper virus epidemic in Serengeti lions (*Panthera leo*). Nature 379:441-445.

Running, S. W., R. R. Nemani, F. A. Heinsch, M. S. Zhao, M. Reeves, and H. Hashimoto. 2004. A Continuous Satellite-Derived Measure of Global Terrestrial Primary Production. Bioscience 54:547-560.

Salkina G.P. Colonization of Lazovsky Reserve by domestic dogs. VIII Far Eastern Conference on Reserve management and studies. Conference Proceedings. Blagoveschensk: Izd-vo BGPU, 2007. Pp. 36-40 (in Russian)

Salmanova, A. 2008. Home range characteristics of Far Eastern Leopards. M.S. thesis. Primorsky Krai State University. (in Russian)

Seal, U. S., and Workshop Participants. 1992. Genetic management strategies and population viability of the Florida panther. Yulee, Florida: U.S. Fish and Wildlife Service.

Stander, P.E., P.J. Haden, H. Koqece, and H. Ghau. 1997. The ecology of asociality in Namibian leopards J. Zool. Lond. 242:343-364.

Strategy for conservation of the Far Eastern leopard in Russia. Vladivostok, 1999. 30 p.

Turner, D. P., W. D. Ritts, W. B. Cohen, S. T. Gower, S. W. Running, M. S. Zhao, M. H. Costa, A. A. Kirschbaum, J. M. Ham, S. R. Saleska, and D. E. Ahl. 2006. Evaluation of MODIS NPP and GPP Products Across Multiple Biomes. Remote Sensing of Environment 102:282-292

Uphyrkina, O., D. G. Miquelle, H. Quigley, and S. J. O'Brien. 2002. Conservation Genetics of the Far Eastern Leopard *(Panthera pardus orientalis)* J. Heredity 93:303-311.

Uphyrkina, O., W. E. Johnson, H. Quigley, and D. Miquelle, L. Marker, M. Bush, and S. J. O'Brien. 2001. Phylogenetics, Genome Diversity and origin of modern Leopard, *Panthera pardus.* Molecular Ecology 10:2617-2633.

Vasiliev N.G. Vegetation. Lazovsky Reserve. Moscow: Agropromizdat. 1989. Pp. 51-73. (in Russian)

Vitvitsky G.N. 1961. Climate. Far East. Moscow: Izd-vo AN SSSR. Pp. 93-177. (in Russian)

Vyshin, I.B., P.F. Fomenko, D.G. Pikunov, D.G. Miquelle, and V.V. Aramilev. 1996. A Plan for Conservation of the Far Eastern leopard: Results of an international conference held in Vladivostok, Russia, October 28 - November 1, 1996(in Russian)

Yudakov, A.G., and I.G. Nikolaev. 1974. Data on biology of Manchurian hare. Fauna and ecology of terrestrial vertebrates of the Far East of USSR. Vladivostok. Pp. 65-74. (in Russian)

Yudakov, A.G., and I.G. Nikolaev. 1987. Ecology of the Amur tiger. Winter long-term observations in the western part of the middle Sikhote-Alin in 1970-1973. Nauka, Moscow. 152 pp. (in Russian)

Zhivotchenko, V.I. 1977. Occupation of the Lazovsky Zapovednik by tigers (Panthera tigris altaica) and their relations with leopards and wolves. Zool. Zhurnal. 51:131-139. (in Russian)

APPENDIX I. THREATS TO THE SURVIVAL OF FAR EASTERN LEOPARDS IN SOUTHWEST PRIMORYE AND THE NEED FOR A REINTRODUCTION PROGRAM

1. Threats to the survival of Far Eastern leopards in Southwest Primorye

Success of a reintroduction program will be dependent upon understanding and mitigating threats to individuals and the population as a whole. Existing threats in Southwest Primorye and nearby China will likely be similar to those that will exist in southern Sikhote-Alin during a reintroduction attempt, and therefore we briefly review the most important threats to the survival of the Far Eastern leopard as a prelude to conservation planning.

1.1. Direct human-caused mortality

One of the main threats to the survival of the Far Eastern leopard is human-caused mortality, most commonly by shooting and snaring. Poaching of leopards results from one or some combination of 3 factors: 1) the potential profit derived from leopard skins and body parts; 2) the perceived competition for food (i.e. wild game meat) by hunters; 3) the conflict that arises from leopard depredations of domestic and semi-domestic animals. Of the three, poaching for profit is likely the most common motive. As with tigers, there is strong incentive to sell leopard parts to the Asian medicinal market, and skins to an increasing national and international market. Poaching can be opportunistic, when hunters happen upon a leopard (with snow providing a relatively easy means of tracking down an individual), or when hunting dogs “tree” a leopard, providing an easy mark for a hunter. But some poachers may be directly targeting leopards with the use of dogs or snares. Although snares do catch leopards unintentionally (when set for badgers or other furbearers), trapping is largely illegal in Southwest Primorye.

1.2. Loss of prey base

Prey densities are a primary factor determining potential densities of large carnivores like leopards. Because of its northern temperate climate, ungulate carrying capacity in Primorye is naturally lower than in more southern zones of Asia, and consequently, leopard densities are similarly low. Leopard densities in some of the best leopard habitat in Southwest Primorye have averaged 1.3-1.5 individuals/100 km^2 over 7 years based on camera trapping (Kostyria, Rybin, et al. unpubl.). Higher densities could only be achieved by increasing ungulate densities. Therefore, after human-caused mortality, maintaining high prey densities is the most important managerial task in retaining a high density leopard population.

1.3. Conflicts at deer farms

In Southwest Primorye, conflicts between leopards and man appear to be most obviously centered around "deer farms", which are large, fenced tracts of land on which sika deer are raised primarily to harvest antlers in velvet for the traditional Asian medicinal market. Although dogs and other domestic animals (calves, goats, chickens) are occasionally killed by leopards, reaction to these relatively rare events is minor compared to the threat perceived by owners of sika deer farms. Dried antlers in velvet can be sold for $600/kilogram (1995 price), and the average male deer will provide approximately 300 grams per year. Therefore, death of individual males that can produce antlers for 5 to 8 years can represent significant loss to deer farm owners. Deer farm ventures are often marginally profitable, and loss of their breeding stock due to leopard predation could potentially substantially impact income. Even when losses are minor, leopard depredation is resented by deer farms owners, as carnivore depredation is resented by livestock owners throughout the world. A common response is to shoot or trap offending leopards. Fence lines that are poorly patrolled are a convenient and accessible spot for poaching activities.

Not only do these deer farms usurp large tracts of land that is often quality leopard habitat, but they also contain high densities of natural leopard prey. Since sika deer are a native species, leopards are incapable of differentiating between captive and wild populations. Leopards appear to have few problems finding ways over or through fences, which then allows them access to readily caught prey.

If the leopard population were more secure, selective removal of depredating leopards may be a legitimate management tool. The population that survived this selective culling regime would theoretically be that percentage of the leopard population that learned to avoid deer farms. However, given the precarious status of the Far Eastern leopard, every death has severe implications to survival of this subspecies. In fact, although it is an unnatural situation, deer farms provide a valuable and reliable source of food for leopards. Given the fact that intensive poaching has substantially reduced densities of prey elsewhere, it could be argued that deer farms may presently be critical leopard habitat in the Russian Far East.

Over the past 15 years, most of the deer farms in Southwest Primorye have been closed. This change is positive in that it reduces the chances of depredation, but it also greatly reduces the amount of available food in some regions of Southwest Primorye, and could subsequently greatly impact the capacity of females to raise young. The implications of this economic change are not yet known for the leopard population, but it could be substantial.

1.4. Habitat loss due to encroachment, logging, and fires

Loss of habitat in Southwest Primorye is due to a number of inter-related factors. Humans cleared much of the land for agricultural purposes over the past hundred years, converting former leopard habitat into farmlands and deer farms. Logging continues at a low level in this region, although there is interest still in the softwoods (pine and fir), and an increasing demand for hardwoods such as oak and ash. Destructive logging continues even within wildlife refuges, not only destroying habitat, but increasing access with logging roads for poachers.

More insidious are the annual fires in southwest Primorye, which are nearly entirely human-caused. Most fires are the result of uncontrolled burning of hayfields (to stimulate spring grass growth), although sparks from coal-fired stoves on railroad cars also ignite ground fires along the railway. Ground fires (leaf litter and grass) burn up to 40% of Khasansky Raion annually in the fall and spring seasons. An ardent, biologically diverse forest complex has been largely replaced by pure oak stands (the most fire-resistant species), or where fires are more prevalent, grasslands predominate. Repeated fires kill shrubs and saplings, preventing replacement of overstory trees. With these frequent fires, eventually oak forests are converted to woodland savannas, and finally, to grasslands. In southern Khasan, there are huge tracts of land that are treeless due to repeated grass fires over extensive periods of time. These fires continue to destroy forest lands and reduce habitat for leopards in Southwest Primorye.

1.5. Infrastructure projects

Villages and agricultural fields already cover the majority of broad valleys and fertile flat lands, where prey and leopard populations likely reached their highest densities before human settlement intensified. In other words, leopards have already been pushed to poorer quality habitats with low carrying capacity, making the population vulnerable to further negative human impacts. Economic activities that negatively impact Far Eastern leopards and their habitat in Southwest Primorye include logging, agriculture, mining, road and pipeline transport.

The construction of the Sakhalin-Khabarovsk-Vladivostok pipeline with plans for a gas refinery plant along its route will likely have significant impact on the leopard population. The pipeline is planned to run very close to the Kedrovaya Pad Nature Reserve and through the Leopardovy Wildlife Refuge.

The massive road improvement project in Southwest Primorye also poses threats, mostly through potential fragmentation of habitat and direct mortality as a result of collisions with vehicles. Several collisions with tigers on roads have been documented in recent years. Greater effort must be focused on ways to minimize the impact of fragmentation that roads create (by creating wildlife overpasses and underpasses where necessary), and on ways to reduce the chances of collisions.

1.6. Isolation of population

The reduction in numbers of the Far Eastern leopard in Russia and North China (see Appendix II) has followed a "classic" extinction pattern. Range contraction, often resulting from habitat loss, leads to fragmentation of the habitat. Forest fragmentation has been clearly documented in both Primorsky Krai and Jilin Province in China. Small leopard populations remaining in small fragments of habitat are subject to localized extinctions due to a variety of potential causes. This is especially true of carnivores such as leopards, which have relatively large land area requirements, are the subject of intense poaching in Russian Far East and China, and are dependent on intact forest ecosystems that contain relatively high densities of ungulate species. The single, contiguous population of leopards in Primorye was fragmented into three isolated populations in this century, and since 1970 two of these three populations disappeared (see Table 1 in Appendix II). In Jilin Province, China, a number of isolated, small populations of leopards decreased over time, and presently there is no evidence that a viable population exists anywhere in Northeast China. Fragmentation and isolation of these populations, therefore, poses a serious threat to chances of survival.

1.7. Genetic impoverishment

Small populations risk genetic impoverishment, inbreeding depression, genetic drift, and an overall loss of genetic variation due to allelic loss or reduction in heterozygosity. There are three good examples of the impact of genetic impoverishment on wild felid populations. The remnant population of approximately 30 adult Florida panthers was found to have a series of genetic problems, including very high counts of sperm abnormality (over 90%), high incidence of crooked tails, and congenital heart defects (Jordan 1994, Seal et al. 1992). Low heterozygosity levels indicated that the Florida panther was inbred and had lost approximately half of its genetic diversity (Roelke 1990). Lions in the isolated Ngoro Ngoro Crater population, all derived from 15 founders in 1962, presently show a lack of genetic diversity, have high levels of abnormal sperm, and appear to be suffering from declining reproductive success. African cheetahs (*Acinonyx jubatus*) have a very high level of homogeneity in the wild, which may make them highly susceptible to disease or other potential perturbations (O'Brien et al. 1983, O'Brien and Evermann 1988).

The single remaining Far Eastern leopard population contains approximately 30 individuals in Southwest Primorye, approximately the same size as the Florida panther population when it was suffering from genetic impoverishment, and has been isolated from other populations for at least 20 years, and more likely for 40-50 years. Therefore, this subspecies should be considered at high risk of genetic impoverishment.

1.8. Potential diseases

Small populations, especially those that may have lost genetic variability, are at risk of being eliminated due to disease epidemics. Recently, canine distemper eliminated at least 45% of the 3,000 lions in the Serengeti ecosystem (Roelke-Parker et al. 1996). Little is known of disease risk to the Far Eastern leopard population, but it is potentially susceptible to any number of diseases carried by domestic cats, dogs, or its prey species. A growing number of reports of tigers with symptoms of canine distemper (and two confirmed cases) suggest that the felid populations of the Russian Far East are facing disease risks that have been little studied. Though little is known about potential disease threats to Far Eastern leopards, its significance should not be overlooked in conservation planning (see Appendix VI).

APPENDIX II. HISTORIC AND PRESENT STATUS OF THE FAR EASTERN LEOPARD IN THE WILD

The Far Eastern leopard is the northernmost of all leopard subspecies. In China, its southern boundary is marked by the merger point with the North Chinese subspecies *P. p. japonensis*. The exact location differentiating the two races is debatable, and due to habitat loss, will probably never be known precisely, although it has been suggested that *P. p. orientalis* may have ranged as far south as Beijing (Heptner and Sludsky 1972). In fact, originally these two subspecies were part of a metapopulation that had clinal variation from north to south, but no clear boundary, as the leopard populations themselves were intermixing with no clear boundaries. Therefore, the differentiation of *P. p. orientalis* and *P. p. japonensis* is largely a recent construct, and may have little taxonomic meaning.

In northern China, leopards extended throughout northeastern ("Manchurian") China, including Jilin and Heilongjiang Provinces (Figure 1), and were originally distributed throughout the Korean Peninsula.

In Russia, information from the previous century is scarce. At the turn of this century the leopard was found throughout much of southern Primorsky Krai (Figure 1), although always at lower densities than the Amur tiger (*Panthera tigris altaica*). According to historical data (Arseniev 1914), the Far Eastern Leopard inhabited the Sikhote-Alin Mountains south of a line from Olga Bay to Lake Khanka. Reports of leopards to the north of this line (e.g. Maak 1859, Mideendorf 1867, Przhevalsky 1870), likely represent individuals dispersing out of the normal range of leopards. According to Pikunov and Korkishko (1993) the northern boundary began at Olga Bay and then runs south

Heptner and Sludsky (1972) report occasional intrusions of leopards far north of this region in northern Primorye (e.g. Bikin River Basin), southern Khabarovsk (e.g. Khor River Basin) and even in the southeastern TransBaikal Region. However, most of these reports probably represent dispersal of individuals from China, and do not permanent establishment of a breeding population. The permanent range of a leopard population in Primorsky Krai at the turn of the century can be delineated as the region south of a line running from Olga Bay to the south paralleling the coast, including the Margaritovka and Milogradovka river basins and then heading west, including the upper reaches of the Ussuri Basin (southern Chuguevsky Raion), extending through the Sineya Mountains and then south along the east side of those mountains to the Ilistaya River, before Lake Khanka forms the northern border to the area around Kamen-Rybolov village. (Arseniev 1914, Heptner and Sludsky 1972, Pikunov and Korkishko 1992) (Figure 1). Heptner and Sludsky (1972) suggest that leopards were found further north, to Dzhigit Bay at 44^{o} N latitude, but permanent habitation was further south.

The range of the Far Eastern leopard has collapsed dramatically in this century. There have been no reports of leopards in either the Small or Large Khingan Mountains in northern Heilongjiang (near the border of Amur Oblast, Russia along the Amur River) for the last 70-80 years. There are an unknown but small number of leopards scattered throughout Jilin Province. Whether leopards still exist in Heilongjiang Province except along the border with Southwest Primorye, is unknown.

The last wild leopard know to exist in South Korean was a male leopard that was caught in the southern part of the country in 1962 and died in a zoo in Seoul in 1967 without having produced offspring in captivity. The Far Eastern leopard probably went extinct in the wild in South Korea in the late 1960s, although some recent, unconfirmed reports suggest that a few leopards may remain in the demilitarized zone between North and South Korea and occasionally from there cross into

South Korea. In North Korea, it is possible that leopards still exist in the wild, especially in the rugged northern region near the Chinese border, and it is also likely that animals from Southwest Primorye in Russia occasionally cross the border into North Korea, but reliable information is lacking.

The distribution and numbers of leopards in the Russian Far East has decreased throughout most of the 20th century, due primarily to habitat loss and hunting. For instance, between 1934 and 1965, 39 skins were officially registered, the actual number of animals killed obviously being significantly more than that.

The first reliable estimate of leopard numbers in Russia was conducted by Abramov and Pikunov (1974) in the 1972-1973 winter (Table II.1). By this time, the population in Primorye had contracted from one contiguous to three isolated populations (Figure 2): 1) in the southern Sikhote-Alin Mountains leopards were most common along the coastal regions, but there were only an estimated 8-10 animals remaining; 2) in the western section of Pogranichny Raion (west of Lake Khanka), primarily within Komissarovka Basin there were 5-6 animals that moved back and forth across the Chinese boundary; and, 3) in Southwest Primorye, including nearly all of Khasansky Raion, and the western sections of Ussuriisky and Nadezhdinsky Raions, there were an estimated 25-30 animals. Therefore, by 1973, there were an estimated 38-46 Far Eastern leopards remaining in Russia, many of which were dependent on habitat on both sides of the Russian-Chinese border.

A census in 1985 by Pikunov and Korkishko (1985) suggested that leopards had disappeared from the western section of Pogranichny Raion. Furthermore, they were not able to confirm the presence of leopards in southern Sikhote-Alin. The population in southwestern Primorye remained approximately the same as the 1972 survey - 25-30 animals. In the 1990-1991 winter a survey revealed the population size in southwest Primorye to be stable, with 30-36 animals counted, if migrants to and from China were included (Korkishko and Pikunov 1994). Since 1997, there have been 6 surveys of leopards in Southwest Primorye. While population estimates ranged from 22-27 to 48-50 (Table I.1), variation in results appears to be more associated with the survey method and authors, while the population appears to have remained relatively stable.

Analyses of habitat use by leopards (Murzin and Miquelle, unpubl.) suggest that all available habitat in Southwest Primorye is presently occupied, and therefore it is unlikely that this population can increase substantially unless there is a dramatic increase in prey availability, or an expansion of the population into neighboring habitat in China.

In southern Sikhote-Alin there have been occasional reports of leopards and leopard tracks during the past 5-10 years (Mezentsev 1997, Gaponov, pers. comm.), but as yet there are no confirmed reports of a stable population of leopards or of even a female with young in the Sikhote-Alin Mountains since the 1972 survey.

Table II.1. Surveys of Far Eastern leopards conducted in the Russian Far East, 1972-2007.

Year	Implementors	Area	Numbers of Leopards
1972-73	V.K. Abramov, and D.G. Pikunov	Southwest Primorye, Southern Sikhote-Alin, Pogranichny & Khankaisky Counties	38-46
1983-84	D.G. Pikunov and V.G.Korkisko	Southwest Primorye	25-30
1990-1991	D.G. Pikunov, V.K. Abarmov, and V.G.Korkisko	Southwest Primorye	30-36
1997	Pikunov et al.	Southwest Primorye	25-31
1998	Aramilev, Fomenko, and Miquelle	Southwest Primorye	40-44
2000	Pikunov et al.	Southwest Primorye	22-27
2000	Aramilev and Fomenko	Southwest Primorye	48-50
2003	Pikunov et al.	Southwest Primorye	28-30
2007	Pikunov et al.	Southwest Primorye	25-34

APPENDIX III. TAXONOMIC STATUS AND GENETICS OF THE WILD AND CAPTIVE POPULATIONS OF FAR EASTERN LEOPARDS

Taxonomy

The leopard, *Panthera pardus*, has the broadest distribution of any felid species in the world, and is one of the most widely ranging carnivores of any terrestrial mammal species, rivaled only by the wolf (*Canis lupus*), puma, (*Puma concolor*), and lynx (*Lynx lynx*). Initially named by Carl Linneaus in 1758 on the basis of a skin thought to originate from Egypt, the leopard has been divided into many subspecies based on geographic regions and differences in color, size, and markings. The Far Eastern, or Amur leopard, *Panthera pardus orientalis*, was described by Schlegel in 1858 based on a skin now housed in the British Museum of Natural History. The official description from Heptner and Sludsky (1972) is:

> Size, not large. Coat fairly soft, with long (on back, 30 to 50 mm, and on the abdomen, 70 mm) and dense hair. Main general color type bright and lustrous. Winter coat varies from fairly light yellow to dense yellowish-red with a golden tinge or rusty-reddish-yellow. Color on flanks and outer sides of legs lighter. Spots pure black color; light-colored centers of circle of spots ("rosettes") somewhat darker than main background color of skin. Spots numerous, i.e., spottiness prominent. Summer pelage shorter and brighter with more vivid coloration pattern. Skull small, with narrow intraorbital region (on average, width about 20% of condylobasal length; post-orbital constriction distinct, short, and in the form of an isthmus; nasal pointed at posterior ends and zygomatic arches relatively massive. Measurement of male (six): body length 107 to 136 cm; tail length 82 to 90 cm; length of hind foot 24 to 27 cm; and height at shoulders 64 to 78 cm. Maximum length of skull 204 to 232 mm; condylobasal length 186 to 200; zygomatic width 129-144 mm; interorbital width 34.3 to 39.9 mm; postorbital width 36.8 to 45.0 mm; and length of upper tooth row 67.8 to 68.7 mm. Weight of males of moderate size--32 kg, and of large ones--48 kg. This weight may even reach 60 to 74 kg.

The differences between Far Eastern and North Chinese leopards (*P. p. japonensis*) are quite minor as there was most likely interbreeding of these two populations originally (Appendix II). As mentioned above, the range of color variability in Far Eastern leopards is quite broad and differences in color intensity and brightness of extreme forms is fairly sharp. Differences in vividness of coloration between winter and summer coats are also distinct. This sometimes creates the impression of the existence in the Russian Far East of two forms (subspecies) of leopard differing in color. The presence of bright-colored specimens has provided some authors a basis for suggesting the occasional or even regular occurrence of North Chinese leopards in the southern Ussuri region.

Far Eastern leopards typically have an extremely thick, long-haired winter coat, an adaptation for survival in the cold climate of the Russian Far East, and are famous for their extremely large, thick-rimmed black rosettes or complete circular markings that cover their body. Leopards from Korea were originally described as a separate subspecies, *Panthera pardus villosa*, but later were synopsized under the subspecies *orientalis*.

Genetics

The Far Eastern leopard survives as a single small relict population that descended from a 19th century Northeast Asian subspecies whose range had extended through eastern Russia, the Korean peninsula and northeastern China. A molecular genetic analysis of leopard DNA collected from the remaining RFE population and from captive animals derived from the North Korean population revealed a marked depletion of population genetic diversity relative to that observed using the same genetic markers in other leopard subspecies (Uphyrkina et al. 2002). This analysis affirmed the subspecies level distinctiveness of the *P. p. orientalis* specimens and also demonstrated a close genetic relationship with the formerly adjacent North Chinese subspecies. *P. p. japonensis*. The observations were evident for individuals from both the RFE and the North Korea, samples of which (although limited to 7 and 5 individuals respectively) showed highly similar genotypes and large amounts of genetic depletion.

The levels of diversity measured are remarkably low, indicative of a history of inbreeding in the population for several generations. The levels of genetic depletion observed in Far Eastern leopards are comparable to the reduction observed in the severely inbred Florida panther (*Puma concolor coryi*) and the relict Asiatic lion (*Panthera leo persica*). Such levels of genetic reduction have been associated with severe congenital and reproductive abnormalities that impede the health, survival and reproduction of some but not all genetically diminished small populations. Such abnormalities have not been observed in the free ranging *P. p. orientalis* population, but recent medical analyses of a limited number of wild Far Eastern leopards provides preliminary evidence that such abnormalities may exist. When considered in the context of non-physiological perils that threaten small populations (e.g. chance mortality, poaching, habitat loss, infectious disease and others), the genetic depletion and demographic data indicate a critically diminished population under severe threat of extinction.

Based on the results of genetic analyses of Far Eastern leopards, the wild population cannot act as a suitable source for reintroduction for two reasons: 1) at such small size, removal of any individual, but particularly adult females, could greatly increase the risk of extinction of that population, and 2) using a subset of individuals from Southwest, a population already genetically impoverished, would lead to even greater genetic loss (as only a sampling of the existing genetic population would be taken) likely resulting in a population so genetically depauperate as to greatly diminish the chances of population persistence.

The captive population of Far Eastern leopards in Russia, Europe and North America was established in 1961 from 9 wild born founders. Molecular genetic analysis of a sampling of 22 individuals revealed that the population contains greater genetic diversity than the wild population. However, that diversity is at least partially the result of representation of a mixture of founders from *P. p orientalis* and the neighboring *P. p. japonensis*. At least two founders (#2 and #89) and their offspring show genetic influence that is diagnostic for *P. p. japonensis*.

Evolutionary coalescent calculations based on molecular genetic distance between subspecies indicate that gene flow between *P. P. orientalis* and *P. p. japonensis* likely occurred in the last 1000 years and as recently as 200 years ago. Thus the captive population would genetically reflect the common gene flow status of a contiguous range of East Asian leopards that had occupied Asia a millennium ago. As such the robust and genetically diverse captive population provides a suitable candidate population – and really the only potential candidate population - for potential restoration of the wild population of *P. p. orientalis*.

APPENDIX IV. CHARACTERISTICS OF LAZOVSKY RESERVE

A.I. Myslenkov

The territory of Lazovsky Zapovednik is a part of the historic range of Far Eastern leopards. The last confirmed report of a leopard in the reserve was occurred in the mid- 1940s (Laptev et al., 1995). Later there were several reports from local people and specialists about visual observations of leopards and their tracks (Khramtsov, Khokhryakov, 1991; Kryukov, 2007). In February and March 1987 a group of specialists searched the territory of Lazovsky and Olginsky Raions for leopard tracks without positive results, suggesting that the Sikhote-Alin leopard population has become extinct at least in the southern portions where they formerly were most abundant (Pikunov et al., 1989). Since 1989 multiple tiger surveys have been conducted in Lazovsky Reserve and Lazovsky Raion, including snow tracking in winter (over 2,000 km of survey routes covered), annual tiger tracks and visual observations on survey routes, scent marks sample collection, etc. Small tracks were paid special attention. Specialists verifying information about small tracks reported by local people or reserve staff usually find them to be tracks of subadult tigers. The presence in leopard in Lazovsky Raion has not been confirmed.

Zhivotchenko (1977) suggests that the extinction of leopards in Lazovsky Zapovednik was associated with the recolonization of tigers in their historic range. Although competitive exclusion cannot be ruled out, it is likely that other factors associated with low population sizes were more important (see section 6.4). In Southwest Primorye the leopard population has been stable in areas where tiger numbers have been increasing; tigers and leopards do not compete in a significant way for prey (Pikunov and Korkishko 1992). Since the presence of leopards in Lazovsky Zapovednik and Lazovsky Raion has not confirmed for about 60 years, there is a need to reintroduce Far Eastern leopards into its historic range to re-establish the full complex of carnivores.

GEOGRAPHICAL CHARACTERISTICS OF LAZOVSKY ZAPOVEDNIK

Geographic coordinates (longitude and latitude) of the Zapovednik

The Zapovednik is located between 42°49′ and 43°′23 N latitude and 133°42 and 134°12 E longitude.

Table IV.1. Coordinates of Lazovsky Zapovednik.

	Central part	Northern part	Eastern part	Southern part	Western part
Latitude	43° 07′	43° 23′	43° 11′	42° 49′	42° 56′
Longitude	133° 58′	133° 59′	134° 12′	133° 44′	133° 42′

The Zapovednik consists of 121,998 ha that is a strictly protected core zone with a surrounding buffer zone of 15,978 ha. Total border length is 240 km, including 36 km along the coast of the Sea of Japan.

The Zapovednik is located in temperate zone of the Pacific climate zone.

According to the geobotanical zoning scheme of Kolesnikov (1963) the main area of Lazovsky Zapovednik is part of the Far Eastern province of Korean pine – broad-leaved forests of Eastern Asiatic conifer-broad-leaved zone. According to faunistic zoning scheme (Kurentsov, 1965) the Zapovednik is part of the Zaussuriisky region of Primorsky-Manchurian province of the Manchurian zone, which is a part of Manchurian-Chinese subregion of the Holarctic region.

Area characteristics and landscape features

The Zapovednik falls within the administrative boundaries of Lazovsky Raion in southeastern Primorsky Krai and is located in the southern spurs of the Sikhote-Alin Mountains between Kievka and Chyornaya rivers. Zapovedny Ridge divides the protected area into a northern inland area and a southern coastal region. Forested mountains are the dominant landscape of the Zapovednik. Mean mountain elevation is between 500 and 700 m above sea level with individual peaks more than 1,000 m above sea level. Steepness of mountain slopes varies, but averages 20-25^{o}, with ridges that are narrow and rocky. Eastern slopes are steeper than western ones. Rock slides cover large areas. elevation of mountains decreases eastward in the direction of the sea, as mountains turn to hills 100-200 m above sea level. Due to the rugged topography and very steep slopes most parts of the Zapovednik are difficult to access.

Two forested islands, Petrova and Beltsova, located near the southern border of the Zapovednik are the part of protected area.

The highest point of the Zapovednik is Chyornaya Mountain – 1379 m above sea level.

Two meteorological stations – Preobrazhenie (operating since 1952) and Lazo (since 1966) are located near Zapovednik borders.

Hydrography

The inland part of the Zapovednik (northwest from Zapovedny ridge) is part of a hydroclimatic zone of excessive humidity, while the coastal area is considered part of an "optimal" humidity zone in average and dry years.

The Zapovednik territory consists of two independent basins of Kievka and Chyornaya rivers flowing into the Sea of Japan. Other numerous rivers and creeks of different size, direction and characteristics are either tributaries of these two rivers or independent streams with narrow coastal basins (about 10 km wide), which flow into the Sea of Japan. The total length of rivers and creeks of Lazovsky Raion is 2,881 km, drainage network has a density of 1.1 km of river flow per km^2, which exceeds average estimates for Primorye (0.73/ km^2) and for Russia (0.22/km^2).

All rivers and streams are fed by local rains, as is typical for a monsoonal climate, and are typical mountainous river systems, with narrow valleys, stony riverbeds, steep gradients (5^{o} and more per km), and rapid flowing. Only Kievka and to lesser extent Chyornaya in their lower reaches are flat, slow moving rivers with wider valleys, branches and oxbow lakes. Several small lakes (Selyushino, Zarya, Topkoe, Latvia, Chukhunenko) are located there, the length of their coastline rarely exceed 3 km. Several lakes have unique aquatic flora and other natural characteristics that are sufficiently unusual to have them recognized as "natural monuments".

The territory of Lazovsky Zapovednik is located between Kievka and Chyornaya rivers and covers only their upper basins. As is typical for rain-fed rivers, in winter and other dry seasons the rivers in the Zapovednik become shallow or even disappear, and become fast-flowing after heavy rainfalls. The lowest water levels are observed in February and early March. Spring floods are generally is absent. There are several warm mineral springs in the Zapovednik territory.

Geology, geomorphology and soils

Regional orography is characterized as a low elevation, rugged mountainous landscape. Formation of current landscape is associated with formation of folded structures of the Mesozoic age, complicated by volcanic activity. The layout of the geographic features generally parallels the coastline.

Brown forest soils are most typical for the most of the Zapovednik. Under conifer forests occurring at the highest elevations of the Zapovednik, there were formerly distributed brown-taiga alluvial-humus soils. Now, the typical soils in this forest zone are brown forest soils, the same as for the conifer-broadleaved forests. Brown podzolized forest soils are typical for Korean pine – broad-leaved and oak forests. In coastal bays and inland plains chernozem soils occur. Overflow areas of rivers and creeks are characterized by new sandy-pebble alluvial deposits.

Flora

According to the geobotanical zoning scheme the majority of Lazovsky Zapovednik is part of the Far Eastern province of Korean pine – broadleaved forests of the Eastern Asiatic conifer-broad-leaved zone. Only a small part of upper mountain forest zone relates to Amur-Sikhote-Alin province of Southern-Okhotsk dark coniferous forest subregion (Kolesnikov, 1955, 1961). Forests are the dominant vegetation type in the Zapovednik. According to forest survey data (collected in 1980) about 96% of the Zapovednik is covered with forest. Prevalent forest formations are oak, Korean pine–broad-leaved, spruce-fir, birch and aspen forests. River bottoms are covered with valley broad-leaved forests. Narrow belts of chosenia and willow occur along the largest rivers. Wide river and creek valleys are covered with poplar stands. The lowest wettest parts of flood-plains are covered with alder. At the highest reaches of forests there are sparse patches of stone birch. Non-forested communities, including shrublands, meadows, wetlands, rocky formations cover small patches of the protected area but are a common characteristic of the landscape in some parts of the Zapovednik.

Present vegetation of the Zapovednik has been strongly influenced by human impact, mostly in the form of forest fires. According to observations of A.F. Budischev (1867) in the middle of XIX century the human impact on forests in southeast Primorye was not significant, but in the 1930s B.P. Kolesnikov (1937) noted: "Forest fires have degraded the primeval vegetation and natural patterns of spatial distribution and interrelations of individual formations and associations so much that they are very difficult to detect and determine." During temporary closure of the Zapovednik (1951-1957) logging activities took place in the most parts of the zapovednik.

Vegetation of the reserve is characterized by distinct zones associated with elevational change, geomorphologic structure of ground surface and influence of the sea. B.P. Kolesnikov (1937) defined 4 vegetation zones on Zapovedny ridge: coastal vegetation, oak, broad-leaved forests and secondary hazel-lespedeza shrublands (up to 400-600 m above sea level), secondary young deciduous forests recovering after forest fires (between 400 and 800-1000 m) and alpine vegetation (800-1300 m). Later P.P. Zhudova specified and detailed this scheme. N.G. Vasiliev (1989) suggested the Zapovednik could be classified into 6 zones.

We suggest there are 4 distinct altitudinal vegetation belts in Lazovsky Zapovednik:

- Coastal vegetation (coastline up to 50-70 m), including maritime meadows, Gmelin's wormwood shrubs, vegetation on rocks and scree near seashore, and vegetation of sandy and pebble beaches;
- Oak, Korean pine-broad-leaved and broad-leaved forests (up to 800-1000 m above sea level);
- Spruce-fir forests (between 700 and 1300 m);
- Stone birch forests and alpine shrubs (above 1100 m).

The fourth zone is fragmentary in the Zapovednik. Borders of vegetation zones depend on aspect and steepness of mountain slopes. On northern slopes boundaries of zones are 200-300 m lower than on southern ones. On eastern, seaside slopes spruce-fir forests are usually absent.

Nearly 50 years of protected status determine two trends in vegetation changes in Lazovsky Zapovednik. First is the restoration of primary forests typical of Primorye in previous centuries. Forests slowly cover rock slides, dry meadows and shrublands which appeared due to human impact in lower and middle mountainous zones. In secondary forest formations (white birch, aspen and linden forests as well as most oak forests) recovery of Korean pine is occurring. The other trend, caused by high densities and excessive numbers of sika deer in the coastal portion of the reserve, is degradation of forest habitats. Sika deer are thinning undergrowth and preventing re-growth, changing the composition of herb species decreasing its projective cover. Excessive impact by ungulates on forest vegetation is preventing normal forest restoration and impacting natural processes in ecosystems of the Zapovednik. Continuous observations and thorough research are needed to understand the rates of vegetation changes in the Zapovednik and to predict the potential consequences.

Fauna

Sixty species (70%) of the 82 species reported in Primorye (and 104 mammal species which occur in the Russian Far East) are found within the present boundaries the Zapovednik. Many mammal species which occur in the Zapovednik are rare and require special protection, such as the Amur tiger and Amur goral. Six species are included in the Red Book of IUCN, 5 in the Red Book of the Russian Federation (2001) and 12 in the Red Book of Primorsky Krai (2005).

In Lazovsky Zapovednik the percentage of species of Manchurian fauna is much higher than in central Sikhote-Alin: sika deer are more abundant than red deer, black bear are more abundant than brown bear, Manchurian hare are more abundant than Alpine hare (belyak).

There is 40 km of indented coastline included in the Zapovednik is 40 km long, which makes Lazovsky Zapovednik unique among protected areas in the Far East in having strong representation of animals associated with the sea. Lazovsky Zapovednik maintains stable populations of large mammals, including Amur tigers, sika deer and Amur goral.

The field mouse and Far Eastern vole are the most abundant mammal species in forest-meadows. This is also a preferred habitat of the Manchurian hare, sika deer and roe deer. In summer wild boars are common in meadows. Raccoon dog, fox, Siberian weasel and Far eastern wild cat are common predators for this type of habitat.

Of the rodents the Asiatic forest mouse and grey-sided vole are the dominant species in oak-broad-leaved forests, which cover 64% of the protected area. Chipmunks are abundant. Squirrels are common in years with good acorns crops from Mongolian oak. Oak forests with hazel and lespedeza underbrush on southern slopes are preferred habitat of the Manchurian hare. Oak forests with glades on mountain slopes, especially close to the seashore are the typical habitat of sika deer. There are numerous sika deer trails along creek valleys, through ridges from southern to northern slopes and along the coastline. Oak forests are preferred habitat for wild boars, which move to Korean pine forests only in years with good crops of pine nuts.

In middle and upper basins of Kievka and Chyornaya rivers Korean pine-broad-leaved forests with associated mammal populations are found. The Asiatic forest mouse, chipmunk, squirrel, sable, badger, red deer and wild boar are common species of this type of habitat. Yellow-throated marten are rare. In the 1990s sika deer dispersed from seashore habitat into the whole of the Zapovednik.

Climatic conditions

Lazovsky Zapovednik is located near the Sea of Japan, with dominant Zapovedny ridge, which is the southern branch of Sikhote-Alin Mountain Range. Zapovedny ridge and its spurs divide the Zapovednik area into an inland and coastal zone. The differences in abiotic environmental factors of these two zones are similar to those of western and eastern macroslopes of the main Sikhote-Alin Range (Matyushkin et al., 1981) due to influence of the sea, but here the differences are not so sharp.

Annual average temperature in the inland part of the Lazovsky Zapovednik is +4.4˚C, while in coastal part the average is +5.6˚C (Nature chronicle of Lazovsky Zapovednik). Therefore annual average temperature across the entirety of the Zapovednik is +5.0˚C, which is similar to annual average temperature in Far Eastern leopard habitat in Southwest Primorye (Pikunov and Korkishko, 1992).

Unlike the western macroslope of the Sikhote-Alin Mountains which are characterized by more continental climate mixed with some features of monsoonal climate (Vitvitskiy, 1961), the eastern macroslope facing the sea is characterized as a purely monsoonal climate. In the coastal part of the protected area the amount of precipitation in summer is higher than inland. Snow conditions along the coastal and inland areas are significantly different with first snowfall in the inland area (50-70 km from the sea) occurring 1-2 months earlier and snow melting later than on the seashore. The total length of time with snow on the ground is 100-120 days in the inland region and only 45-90 days along the seashore (Poddubnaya, 1995). In winters with little snow it is nearly absent along the coast. In the most recent 10 years stable snow cover appeared at the middle or end of December, except in the 2000-2001 winter season, when stable snow cover had formed by early winter. After forming a stable snow cover the average 10-year snow depth in the coastal zone is only 7 cm, whereas inland it is 20 cm. At the end of winter the average snow depth in river valleys in coastal area is 24 cm, while inland it is 43 cm.

Snow conditions in Lazovsky Zapovednik are similar to those in leopard habitat in Southwest Primorye, where snow cover forms by the mid-December and snow period is 86-107 days (Pikunov and Korkishko 1992). Snow depth increases inland, but rarely exceeds 30-40 cm (usually 10-15 cm), although in some winters snow depth has reached 70 cm. In some years a stable snow cover is nearly absent.

Snow distribution determines the distribution and density of sika deer, which is one of the main potential prey species for leopards in Lazovsky Zapovednik. Severe winters with extremely deep snow are one of the factors limiting sika deer distribution (Bromley and Kucherenko 1983; Makovkin, 1999). However in the coastal part of the Zapovednik southern slopes often become free of snow shortly after snowfall, as occurred in the snowy winter season of 1996-1997. In this winter in late January and February snow depth inland was 43 cm on average, while in coastal areas at the same time snow depth was only 32 cm. During the range-wide survey of Amur tigers in winter 1995-1996 in early February snow depth in valleys on the western macroslope of Sikhote-Alin was 40-60 cm, at the same time in Lazovsky Zapovednik it was only 15-25 cm and a narrow belt along the coastline was partially free of snow (Matyushkin et al., 1996).
Therefore, leopard habitat conditions in Lazovsky Zapovednik only slightly differ from those in the present leopard range in Southwest Primorye. During the past 10 years snow distribution patterns have not changed significantly.

Average temperature during August, the hottest month of the year is +19.7°C, and the average temperature during January, the coldest month of the year, is –10.5°C. Average yearly rainfall is 712 mm.

Status of prey base

Five species of ungulates occur in Lazovsky Zapovednik: sika deer, red deer, roe deer, wild boar, musk deer and goral. The main prey of leopards is likely to be sika deer and roe deer, which are the primary prey of leopards in Southwest Primorye. Roe deer are distributed primarily in the river valleys, in sparse oak forests, open fields and meadows. They are rarely found in the central part of the Zapovednik, and therefore they number only approximately 300 individuals.

Sika deer occur throughout the Zapovednik, from the sea coast to the northernmost border near Lazo village. For the past 10 years numbers of this species have remained at high and relatively stable numbers (Table IV.2). An aerial survey in 2004 resulted in an estimate of sika deer numbers of 4150, with three zones of density: the inland zone (Chyornaya and Perekatnaya river basins) retained densities of 24.2±6.9 individuals/1000 ha; the central portion of the Kievka basin had densities of 69.9±13.4 individuals/1000 ha, and the coastal zone (Sokolovka and Proselochnaya river valleys and Petrovskaya pad) have the highest densities – 141.2+23.8 individuals/1000 ha. All estimates are statistically rigorous. Construction of a leopard breeding center is planned in the middle basin of Kievka river.

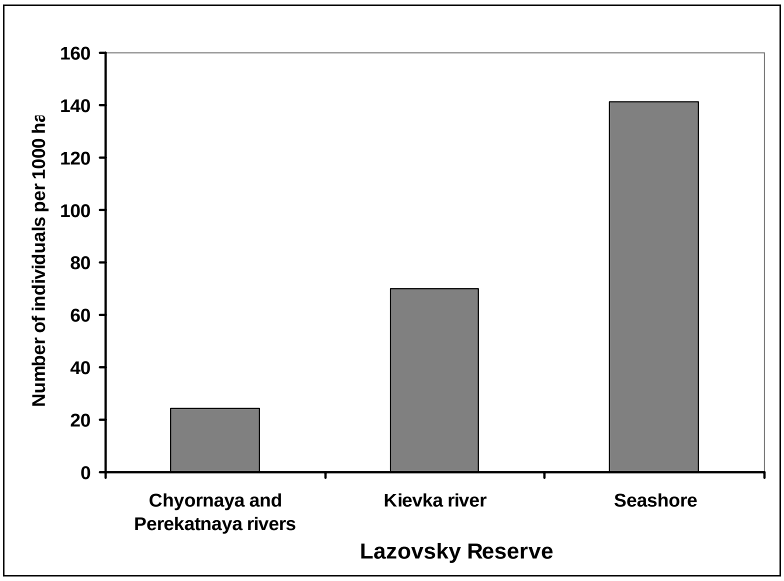


Figure IV.1. Sika deer density in 3 areas of Lazovsky Zapovednik, 1997-2008.

High sika deer densities will provide sufficient prey for tiger and the potential leopard population.

Raccoon dogs, badgers, and Manchurian hare are secondary prey species for leopards. These species are common in the Zapovednik and even abundant in some areas. Raccoon dog and badger numbers are relatively stable. However, despite the fact that Lazovsky Zapovednik is a part of area with highest densities of Manchurian hare (Yudakov and Nikolaev, 1974), its population is decreasing in the recent years (Table IV.2).

Table IV.2. Winter transect count estimates in Lazovsky Zapovednik in 2003-2007 (number of fresh (≥ 24 hours) tracks per 10 km of survey routes)

Species	2003	2004	2005	2006	2007
Sika deer	261,9	65,6	107,1	105,1	138,9
Roe deer	1,0	5,6	8,6	2,4	0,7
Red deer	2,1	1,8	7,1	3,4	2,0
Wild boar	16,4	8,5	8,1	4,6	1,9
Manchurian hare	25,4	3,1	3,2	1,1	0,7
Lynx	1,2	0,1	0,4	0,1	0,6

Human impact

Today there are 30 km of forest roads within the Zapovednik territory (including its boundaries), i.e. roads passable for vehicles. The Lazo-Preobrazhenie road in Kievsky Forestry District intersects the Zapovednik territory over 4 km. A forest road to Petrova Bay (8 km) is regularly renovated, as well as mineral fire breaks along the Zapovednik borders.

The number of fires (mainly human induced fires) (Table IV.3.) and burnt areas in the Zapovednik mainly depend on weather conditions in the fire-risk period. However fire-fighting activities in the Zapovednik and adjacent areas result in significant decrease of fires and burnt areas.

Table IV.3. Ground fires in Lazovsky Zapovednik, 1995–2008.

Year	Number of fires		Burnt area, ha		
	Zapovednik	Adjacent area	Zapovednik	Including forested area	Adjacent area
1995	5	21	269.8	269.8	415.7
1996	3	14	6.3	6.3	219.3
1997	7	7	310.4	310.4	452.9
1998	4	13	361.1	361.1	1647
1999	1	6	2.5	2.5	64
2000	2	9	290	290	480
2001	6	14	115.6	115.6	1072
2002	3	10	7.5	7.5	795
2003	4	8	148	148	369
2004	23	14	4019.7	4019.7	711
2005	4	7	155.9	155.9	190
2006	5	3	84.5	84.5	125
2007	no	no			
2008	3	14	44	44	198

Logging is not conducted in the Zapovednik. Trees and bushes are cut down occasionally along the power transmission lines (about 25 ha), which intersect the Zapovednik territory. In summer the Zapovednik is visited by tourists, which stay mainly in the coastal area of the Zapovednik or in adjacent Petrova Bay.

Fifteen settlements are situated within 30 km of the Zapovednik. The total human population as of Jan. 1, 2007 was 18,600 persons and is gradually decreasing.

Ungulate poaching occurs mainly along the Zapovednik borders and adjacent areas. Today the main cause of ungulate mortality in Lazovsky Raion is poaching. Of the 1076 cases of ungulate mortality for which cause was determined between 1997 and 2006, 63.4% were poached, 12.1% were killed by tigers, 2.6% were killed by dogs and 0.8% were killed by other predators. All other ungulates (19.9%) died of starvation or accidents (1.3%).

Fires and poaching are the main human impacts in the Zapovednik. While fire-fighting activities in the Zapovednik are effective, anti-poaching measures should be intensified, especially in areas adjacent to the Zapovednik.

Potential competitors and enemies

Leopard potential competitors in Lazovsky Zapovednik are tiger, lynx, wolf, yellow-throated marten, brown and Himalayan bears as well as domestic and wild dogs.

Based on expert assessment tiger numbers fluctuated between 1997 and 2008 from 8 to 12 individuals in Lazovsky Zapovednik and from 4 to 8 in adjacent unprotected “Lazovsky Raion” monitoring unit (Figures IV.2; IV.3). This unit (988 km2) is situated in Krivaya River basin and adjacent seashore area. Average number of adult tigers in the Zapovednik is 10±1 individuals (SD=1.36, P≤0.05), number of cubs - 4±1 individuals (SD=2.36; P≤0.05). In adjacent unprotected area average number of adult tigers in the Zapovednik is 5±1 individuals (SD=1.12, P≤0.05), number of cubs - 2±1 individuals (SD=1.36, P≤0.05). Difference between the number of adult tigers and cubs in the Zapovednik and adjacent unit was statistically significant (N=22, F=2.15, p<0.0001 – for adults, and N=22, F=1.15, p<0.0233 for cubs. N – number of observations, F – Fisher criterion, p – significance level).

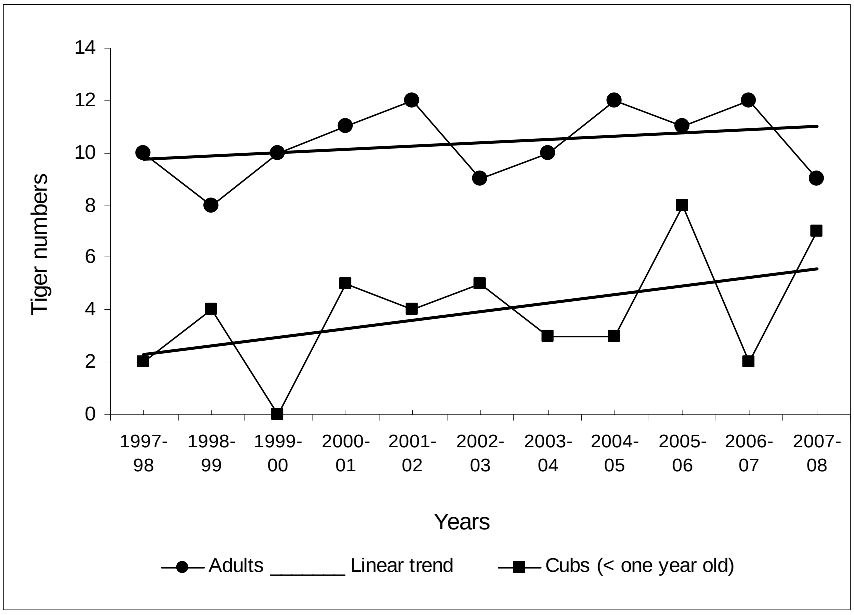


Figure IV.2. Tiger numbers (adults and cubs) and linear trends in Lazovsky Zapovednik, 1997-2008.

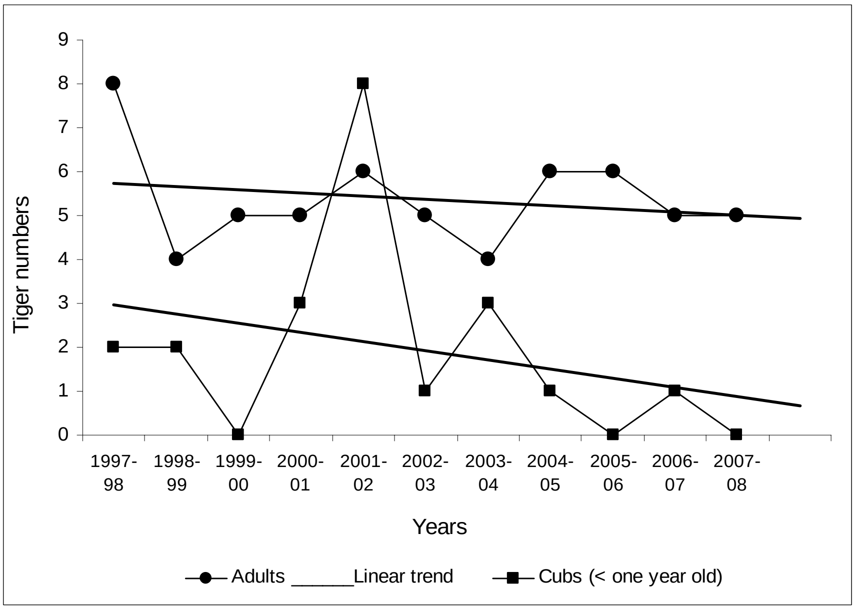


Figure IV.3. Tiger numbers (adults and cubs) and linear trends in "Lazovsky Raion" monitoring unit, 1997-2008.

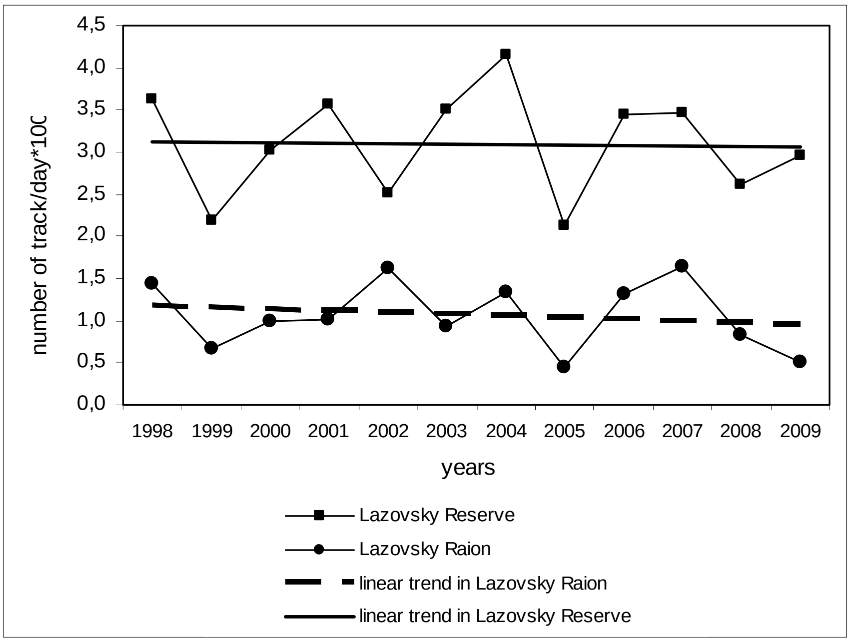


Figure IV.4. Tiger track densities in Lazovsky Zapovednik and "Lazovsky Raion" monitoring unit, 1997-2008.

Density of tiger tracks (tracks/100 km/days since last snow) as an indicator of relative tiger abundance averaged for 11 years of monitoring was 3.07±0.38 tracks (SD=0.64) in Lazovsky Zapovednik, and 0,98±0,24 tracks (SD=0.38, Figure IV.4) in Lazovsky Raion. The difference between average track densities in these two monitoring units was also statistically significant (N=22, F=4.37, p<0.0001).

Average proportion of survey routes where tiger tracks were not recorded during two winter counts was 7±5.74% (SD=9.72) in Lazovsky Zapovednik, and 21±12.21% (SD=20.66; Figure IV.5) in Lazovsky Raion. The difference between these two indicators was also statistically significant (N=22, F=1.25, p<0.0485).

The density of adult tigers in the Zapovednik fluctuated from 0.7 to 1 individual/100 km^2, density of adult tigers and cubs – from 1 to 1.6 individuals/100 km^2 for 11 years of monitoring. Density of adult tigers in Lazovsky Raion fluctuated from 0.4 to 0.8 individuals/100 km^2, density of adult tigers and cubs – from 0.6 to 0.8 individuals/100 km^2 for 11 years of monitoring. However, given the fact that home ranges of adult tigers stretch beyond the territory of these monitoring units, actual tiger density is lower.

The main prey of tigers (which would be the main competitors for prey with leopards in the Zapovednik) is sika deer (Figure IV.6). Other potential prey species of leopards (roe deer, raccoon dog, badger, Manchurian hare and others) are not significant for tigers in winter period. Tiger scat analysis showed a wider range of prey species in the diet, including: hair of squirrel, Siberian weasel and mouse-like rodents as well as hedgehog remains. Based on data by Zhivotchenko (1981) tiger prey species in Lazovsky Zapovednik and adjacent areas include species mentioned above (except mouse-like rodents) as well as wolf, Manchurian hare, hazel-hen and salmon (sima).

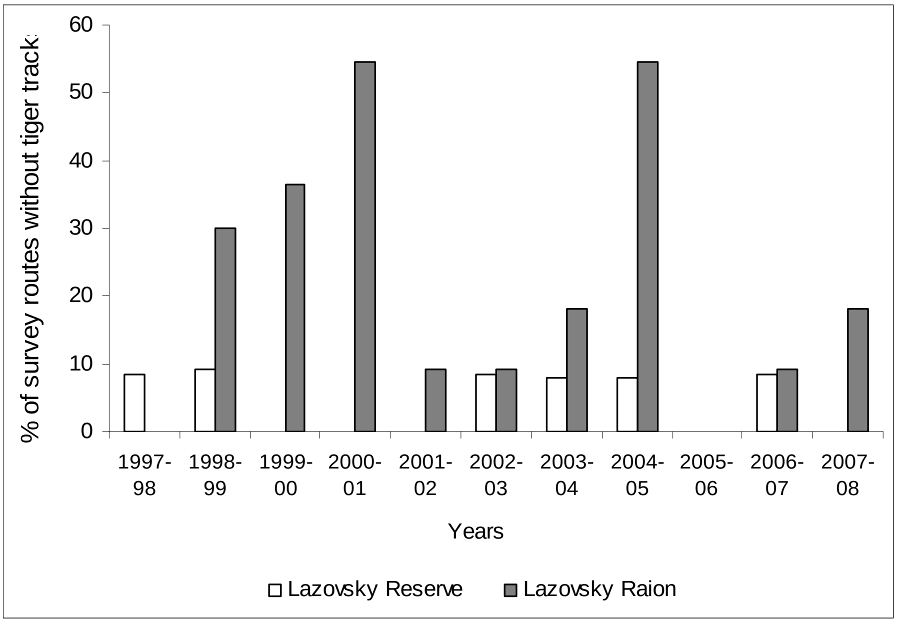


Figure IV.5. Proportion of survey routes where tiger tracks were not recorded, Lazovsky Zapovednik and Lazovsky Raion, 1997-2008.

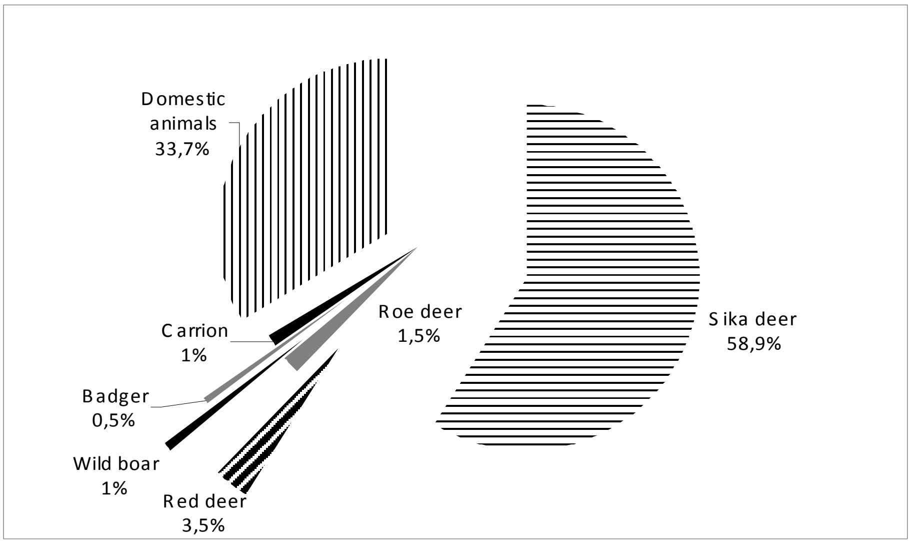


Figure IV.6. Tiger diet (species percentage) in Lazovsky Raion, 1997-2006.

Lynx in the Zapovednik are not abundant, and numbers do not exceed 8-12 individuals. Yellow-throated marten are also relatively rare: their tracks are recorded almost every year, but their kills were found only several times. Between 1981 and 2001 remains of one sika deer and one roe deer killed by yellow-throated marten were found. Between 1970 and 2006 ten kills of lynx were found, including 6 sika deer, 2 roe deer, one raccoon dog and one hare. Therefore, presently predation by lynx and yellow-throated marten on ungulates (potential leopard prey species) is exceptionally rare and their presence does not significantly impact ungulate populations in the Zapovednik.

Since tiger recolonization of its former range in southeastern Sikhote-Alin in the middle of 20^{th} century wolf numbers have decreased, and the population has became fragmented. The distribution of wolves has also changed (Zhivotchenko 1977). Based on data from Yudin (1992) wolves are nearly absent across the entire range of tigers in the Russian Far East. Wolf tracks are recorded in Lazovsky Zapovednik intermittently, and kills by wolves even more rarely. Based on track observations wolf numbers were higher in the early 1990s and then decreased. However observers can confuse wolf tracks with dogs tracks because the number of dogs in the forest increased.

A different situation exists with dog predation. Today dog predation is recorded almost every year and significant proportion of sika deer killed by dogs, with percentage of total kills (of all predators) reaching 17.9% in some years. Domestic and feral dogs may deplete sika deer population in some areas of the Zapovednik (Salkina 2007).

Snowy winters apparently have little influence on the number of dogs in the forest, although a decrease in dog numbers after 1993 is likely due to the snowy winter of 1993-1994. Since 1997 feral dogs are usually observed and shot by Zapovednik patrol groups despite snowy severe winters. Dog numbers in the forest are continuously increasing, and whole packs of domestic dogs can stay for a short period in the forest and then return to settlements. During the entire period of observation only one such dog was killed by tiger. During the same period 35 dogs were killed by tigers in settlements (according to the poll data number of dogs killed by tigers is much higher). Sometimes tigers ate the remains of sika deer killed by dogs.

Two bear species occur in Lazovsky Zapovednik, and they can remain active in winter if the weather is mild and food resources (such as acorns and/or pine nuts) are abundant. In such winters bears can eat the remains of tiger kills. Bears will also use carrion more readily than tigers. Bears rarely kill ungulates and other potential leopard prey species. We never had reports of tigers chasing lynx, wolf or yellow-throated marten, however two tiger scats containing lynx claws were found.

Based on our observations lynx do not avoid tiger tracks and show no particular interest in them, sometimes walking some distance following tiger tracks.

Tiger kills were mostly found in river and creek valleys while lynx kills usually occur in upper river basins and on mountain slopes in winter (Poddubnaya 1995). Lynx tracks at tiger kills were not recorded.

The above information suggests that tigers are likely to be the main competitor of leopards in southeast Sikhote-Alin. Although small species represent insignificant part of tiger diet (Figure IV.5), it is likely during the warmer months they become more important in the tiger's diet, coincident with reproduction period for these prey species. Therefore competition between tiger and leopard for the prey will increase in the warm period at the same time that prey biomass increases.

Since the 1990s domestic and feral dog predation on wild ungulates has been increasing. Dogs could also chase leopards. However forest patrol guards eliminate dogs in the protected and adjacent areas and their impact on ecosystem processes within the Zapovednik depends on intense patrolling of forest patrol guards. Intensive protection of the Zapovednik territory from dogs can minimize their impact on wildlife populations.

Therefore, within the Zapovednik territory competition between leopards and tigers (and probably other predators) for prey will not be significant. Moreover tigers do not usually chase their potential competitors.

APPENDIX V. CHARACTERISTICS OF SOUTH SIKHOTE-ALIN

V.V. Aramilev

The following characteristics are important for leopard reintroduction in southern Sikhote-Alin: relief, climate, vegetation, fauna and human impact.

Based on a description of their historic range (Appendix II) suitable habitat for leopard reintroduction is likely to exist south of a line from Olga Bay to Lake Khanka in the Korean pine-broadleaved and broadleaved forest zone. This is hilly, low to moderate elevation mountainous terrain. The best habitat is situated in hilly and low-mountainous area adjacent to the coast of the Sea of Japan.

The best habitat for leopards is likely to be the Korean pine-broadleaved and broadleaved forests. They cover the area from the seashore to 600-800 m above the sea level. Elevations of more than 700 m are usually covered by Korean pine-spruce and spruce-fir forests. Korean pine-broadleaved forest zone contains patches of small-leaved forest which appear after forest fires.

The southern Sikhote-Alin area is a typical mountainous terrain in southern part of the eastern slopes of the Sikhote-Alin Range. The highest mountain peaks (up to 1472 m above sea level) are situated on the border between Chuguevsky and Olginsky administrative districts. Most of the terrain does not exceed 900 m above sea level.

The character of the Sikhote-Alin Mountains is the result primarily of tectonic uplift, which includes sedimentary rocks, along with crystalline and metamorphic rocks such as sandstone, limestone, and flinty slat. In spots there exist outcrops of granite and basalt.

The southern Sikhote-Alin Range is characterized by extensive system of spurs extending from the main ridge to the east and south. Mountain ridges systematically divide into a series of secondary ridges and outcroppings, forming a complicated, fragmented terrain with dramatically variable relief. The highest peak – 1471.9 m – is Gorelaya Mountain on the border between Chuguevsky and Olginsky administrative districts. Due to the rugged relief mountainous slopes are relatively short and steep.

Based on relief the area can be characterized as consisting of four parts. The first is the coast of the Sea of Japan with bays, wide sand or narrow pebble beaches and coastal rocky ledges. The height of cliffs along the coast varies from 30-50 to 100-150 m. The second part, situated in foothills and valleys of rivers and smaller creeks, is characterized by gentle mountain slopes. The third part is middle mountain zone (400-900 m) with slopes of moderate steepness. There are many outcrops of easily basement rock, which form deposits up to ten meters thick. The fourth part is situated above 900 m above sea level and includes the major divides between river systems. There are many outcrops of dense basement rock, mostly quartz porphyries and andesites. Slopes are sometimes greater than 40 degrees.

The zone of broadleaved and Korean pine-broadleaved forests in South Sikhote-Alin is characterized by monsoonal climate with abundant precipitation in summer and relatively little snow in winter. The western macroslope of southern Sikhote-Alin Range is characterized by a more continental climate.

The climate of the eastern macroslope of southern Sikhote-Alin Range is influenced by the Pacific Ocean and seasonal Eastern-Asiatic monsoons. The comfort period is 45-80 days. In winter northwestern air masses from Central Asia and Siberia brings cold airflow, which provide sunny winters with little snow. Thaws with air temperature + 3^0-4^0C are caused by warm air masses brought by southern winds. Summer monsoons from the east and southeast bring moderate warm and humid airflows from Japan Sea and Yellow Sea, which cause warm humid summer.

The growing season occurs (with temperatures at + 5^0 C and higher) from April 15-20 till October 25-30, averaging 190 days when the average temperature is + 13^0 C. The strongest winds (about 20 m/sec) coming from the northwest are typical in winter. The average wind speed is 4-6 m/sec, recurrence of wind speed 5 m/sec is 30-40%. The coastal zone is characterized by frequent fog and strong sea winds.

Average date of first snowfall is November 20th. Average date of snow disappearance is April 7th. The greatest depth of snow cover is 70 cm, the least – 2 cm, and average snow depth is 10-30 cm. Depth of frost penetration averages 98 cm, with greatest depth at 150 cm. Average date of river ice freeze-up is November 19th, and the average date of river ice break-up is April 9th. Average date of the first frost in the fall is September 28th, of the latest frost in spring – May 22nd. The duration of winter is 100-120 days. Variation of temperature during 24 hours in July and August can reach 20-25^o C, in November when frost occurs – more than 30^oC. Floods are rare in spring due to relatively little snow and continuous snow melting. Abundant long summer rains and monsoon rains often result in floods. Overall the regional climate is characterized by cold winters with little snow, droughty late springs and early summer, excessively humid July and August and warm and dry fall. More severe conditions with great daily variation of meteorological indicators are typical for upper river basins. Average annual temperature in these areas is about – $2{,}5^0$ C, duration of vegetative period is 100 days or less, snowless period is about 90 days and frostless period is no longer than 60-70 days. Annual precipitation is no less than 1000 mm. These areas are characterized by severe northern winds, which are strongest in winter period.

Blowing snow is typical for this area. Snow is blown away from open mountain tops and ridges as well as from windward southern slopes and accumulates only in deep hollows on northern slopes resulting in huge snowdrifts.

Weather conditions in specific areas are determined by cyclonic processes, including position relative to the axis of the Sikhote-Alin Range (stretching from northeast to southwest along the coastline of Japan Sea), by proximity to the seashore and by position in the system of ridges and slopes of different gradients and aspect. Mild maritime climate with cool and humid summers and relatively warm winters are typical for the seashore, mountain valleys and seaward slopes. Continental climate is typical for ridges tops, northern and western slopes, valleys and hollows isolated from marine airflows. On top of these generalizations there also occur temperature inversions when elevated areas are warmer and more humid than those in the lower part of the mountain. Local winds add to this complicated weather pattern: breezes in narrow seashore zones and hot dry winds in inland territories. This area is characterized by typical monsoon climate, with airflow direction changing between summer and winter. Rugged relief and influence of the sea determine both vertical and horizontal changes of weather conditions. Inland, the winter is relatively severe and characterized by deep snow cover. Average temperature in January is -19-20^o C, absolute minimum air temperature on ground surface can be -45^o C. In late October and early November stable snow cover is established in the mountains. In late February snow depth reaches 50-60 cm and in snowy winters can exceed 1 m in mountainous hollows and other windless places. Thaws are frequent along the coastline. Deep snow winters recur every 9-11 years. Spring comes in the second half of March. Due to the many sunny days (20-25 sunny days on average in March-May) and fast increase of air temperature snow melts quickly. In the upper elevational belt, where frost can occur through the second half of May, the remains of ice mounds can be found in narrow shady folds till the middle of May. Summers are warm, with the average temperature of July and August 19–20^oC. The first frost in the fall happens in the second half of September, and in the first half of October mountain tops are usually already covered with snow. Average annual air temperature in inland part of this area is 2.4–2.7°C. Average frostless period is 105-125 days. Annual level of precipitation is 700-800 mm. In coastal areas the winter is milder and less snowy. Average air temperature in January is -11-12°C, absolute minimum temperature is -30°C. Although spring comes here much earlier than in the mountains, the temperature increases much more slowly. Due to the frequent fogs and cold sea influence the number of sunny days is 2-3 times less than inland.

Phenologic stages of vegetative development in coastal areas lag 1.5-2 weeks behind inland areas. In late May and early June when it is foggy, cool and humid in coastal areas and trees are not yet in leaves, inland areas are sunny and trees are in bloom. The summer in coastal areas is cooler, cloudy and more humid. The air temperature of the warmest month – August – in coastal area is 2-2.5°C less than inland areas.

According to the scheme of "Forest zoning of the Russian Far East" by DalNIILH this area is a part of Terneysky-Olginsky district of South Sikhote-Alin forest region, which is a part of Primorsky-Ussuriisky forest oblast. According to the geobotanical zoning scheme of Kolesnikov (1963) this area is situated in conifer-broad-leaved, mountainous dark conifer and broadleaved forest zones within two (Manchurian and Okhotsk) floristic regions of the Far East. The border between these two regions lies along the main ridge of Sikhote-Alin Range within 800-900 m above sea level, and within 1000-1200 m above sea level in southern part of the range.

Ninety percent of the area is forested. Forests are evenly distributed throughout the area excluding agricultural lands in river valleys. However the main forest types are distributed unevenly. Non-forested areas (meadows, hayfields, and pastures) are situated in river and creek valleys, bare mountain tops and rock slides are typical for divides and steep mountain slopes. Current vegetation types have been developed under natural conditions (climate, relief, mother beds, hydrological regime, soils) and human exploitation. The number of forest types increases with elevation and secondary vegetation types.

Coastal vegetation covers the narrow band 1-2 km wide along the coast up to 100-150 m above sea level. Shrub oak is typical for this area. Oak forests occupy the area 20-45 km from the shoreline and up to 600 m above sea level. Secondary oak forests dominate here as well as hazel and lespedeza bushes, secondary meadows and rock slides covered with lichen. Secondary oak and birch forests as well as mixed broadleaved forests occur in this area. Chozenia and elm stands are typical valley forest formations. Siberian dwarf pine cover only some mountain tops.

In low mountainous areas Mongolian oak forests dominate and stretch inland. Vegetation in low mountainous areas has been greatly impacted by human activities, and especially by regular forest fires. Primary forest formations have been destroyed and Korean pine - broadleaved forests were replaced by secondary unproductive oak forests and shrublands. Individual trees and small stands of Korean pine and black fir provide a seed source for recovery of conifer forests. Korean pine forests on steep southern and western slopes were replaced by dry oak forests.

Recovery of young oak sprouting around seed trees happens quickly, ensuring a clumped pattern of understory trees and of woody biomass. Korean pine recovers well. In the absence of fire oak will be replaced by oak-Korean pine forests. Timber volume of 80-100 year forests yields 70-120 m^3/ha. Timber of the forest community has a two-tiered age structure (from young regrowth to large boled trees). Oak is the dominate component of the timber reserve, but occasionally individual specimens of birch (Manchurian and black), Amur basswood, Manchurian ash, Korean pine, small-leaved maple, and Amur corkwood are found in the overstory canopy. Usually the overstory is partly open, at a height of 10-20 m, with tree diameter of oaks, the single large species, usually at

30-70 cm DBH. Less frequently the overstory is denser, and generally the understory is even denser. Lower canopy height is 3-10 m, with diameter of oak 10-20 cm DBH. Timber reserves of stands 120-140 years old averages 15-250 m^3/ha. In many plantings regeneration of oak, Manchurian birch, small-leaved maple, and occasionally Amur basswood, and ash can be found, and Korean pine regrowth is common. Oak forests are widely distributed across gentle and moderately steep slopes on all aspects, as well as wide plateaus that divide watersheds and well-drained river basin terraces. Acorn crops are abundant in oak stands every 2-3 years.

The undergrowth is comprised of many types of shrubs, but is dominated by lespedeza and Manchurian and Siberian ginseng. Lianas include two types of actinidia (Kolomikta and bitter), grape, and schisandra. The grass cover is also diverse.

Forest of spruce and fir comprise a small proportion of the region, occurring in the elevation zone of 800-1300 m above sea level, and is most characteristic on northern slopes and headwaters of rivers. These forests typically have fern and green moss understories. Fern-fir forests occur on the lower regions of gentle slopes and headwater river valleys, while green moss fir stands typically form the upper boundary of large timbered forests. Stone birch forests do not form an independent elevation zone, but usually stone birch is not part of the mountain fir forests.

The subalpine zone is comprised of Japanese stone pine and to a lesser degree stands of microbiota, endemic to southern Sikhote-Alin. Microbiota is only found on exposed rock outcrops.

Mountain tundra communities are found scattered across only the highest mountain tops and do not form their own elevation zone.

Fauna of the southern Sikhote-Alin are typical representatives of the Manchurian faunal complex. Sika deer, roe deer and wild boar are the most important ungulates for the Far Eastern leopard. Red deer occur inland in southern Sikhote-Alin 30-50 km from the coast and from 400-500 m above sea level. Among small carnivores badger and raccoon dog are potential leopard prey species in southern Sikhote-Alin. The increase in sika deer distribution and numbers is favorable for reintroduction of Far Eastern leopards in southern Sikhote-Alin. For the last 25 years the range of sika deer has extended into a continuous band 30-70 km wide along the coast. Sika deer extend 80-100 km inland along river valleys. Sika deer are a distinctive indicator of leopard habitat. According to Pikunov and Korkishko (1993) in the 1970-80s sika deer was a significant part of leopard diet in Southwest Primorye. According to Aramilev and Belozor (unpublished data) currently sika deer is the main prey species for leopards in Southwest Primorye.

Human settlements are unevenly distributed across southern Sikhote-Alin. The highest human population densities occur in the southern and western parts of southern Sikhote-Alin, including regions south of the Vladivostok-Nakhodka highway and the east of Vladivostok-Khabarovsk highway. The central and especially eastern parts of southern Sikhote-Alin are less populated.

There are two strictly protected reserves in southern Sikhote-Alin: Lazovsky State Nature Zapovednik and Ussuriisky State Nature Zapovednik with total area of 1529 km^2, as well as Vasilkovsky Wildlife Refuge and several well-managed hunting leases.

Hunting Leases

The following hunting leases include potential habitat for a leopard reintroduction: Southern Valley, Medved, Bars and Barkhat.

Southern Valley. Annual surveys of game animals are conducted in Southern Valley hunting lease. The main survey method uses count units after the hunting season. Winter transect counts were conducted formerly by the State Hunting Control Service. Data on some game species was based on hunters' poll. The numbers of game species over a recent 3-year interval are given in Table V.1.

Table V.1. Numbers of game animals in South Valley Hunting Lease in 1999-2001

#	Game species	Number of animals		
		1999	2000	2001
1.	Red deer	351	304	261
2.	Wild boar	585	348	258
3.	Roe deer	1112	572	613
4.	Sika deer	1991	2970	2939
5.	Musk deer	200	176	173
6.	Sable	739	403	530
7.	Otter	46	16	34
8.	Raccoon dog	170	180	160
9.	Lynx	94	85	10
10.	Siberian weasel	28	175	193
11.	Mink	244	193	217
12.	Arctic hare	220	74	73
13.	Manchurian hare	340	224	240
14.	Squirrel	6100	759	246
15.	Hazel hen	1154	4216	1570
16.	Brown bear	69	46	35
17.	Himalayan bear	81	45	45

Abundance of raccoon dog, lynx and yellow-throated marten is determined by mapping of hunting. Data on fox and badger is not available because these species are not currently hunted in "Southern Valley". Although sika deer are listed in Red Book and hunting is prohibited on this species specialists of "South Valley" include the sika deer census in count units.
Data on bear numbers is difficult to obtain using existing methods because bears leave their dens for a long period and we can count only part of bear population during any given period. Spring 1999 provided good conditions for the census because after a good harvest of pine nuts bears left their dens earlier when snow cover still remained and we were able to count the majority of the bear population.

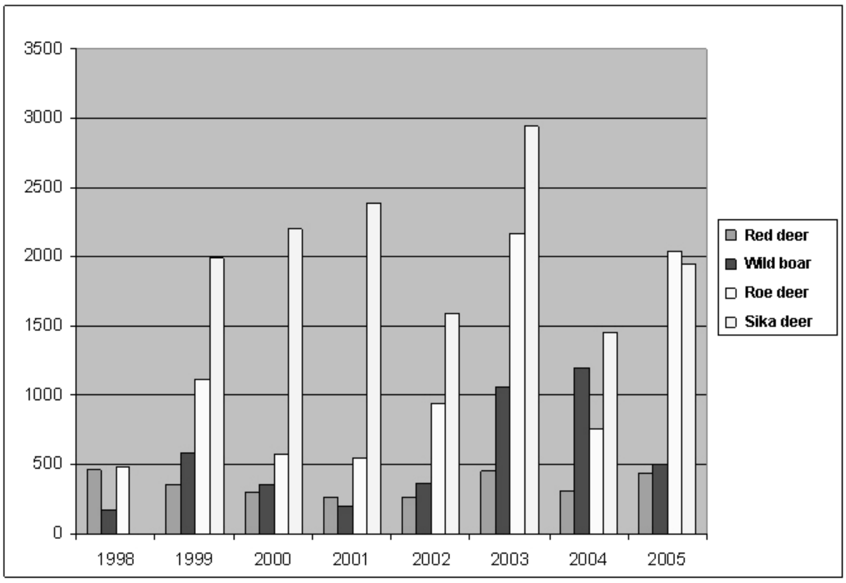


Figure V.1.Population dynamics of major ungulate species in Southern Valley Hunting Lease, based on counts after the hunting season, 1998-2005

Table V.2. Density and numbers of main game species in Southern Valley Hunting Lease in 2001.

Species	Habitat type	Density, individuals/ thousand ha	Size of habitat type, thousand ha	Number of individuals per habitat type	Total number of individuals
Sable	Broadleaved forests (hills)	4.5	49.9	225	774
	Broadleaved forests (low mountains)	3.2	57.75	185	
	Coniferous-broadleaved forests (low mountains)	7.8	29.67	231	
	Dark coniferous forests	2.4	29.62	71	
	Small-leaved forests	2.7	23.07	62	
Siberian weasel	Broadleaved forests (hills)	2.5	49.90	125	206
	Broadleaved forests (low mountains)	1.4	57.75	81	
Red deer	Broadleaved forests (hills)	1.0	49.9	50	503
	Broadleaved forests (low mountains)	1.8	57.75	104	
	Coniferous-broadleaved forests леса (low mountains)	5.9	29.67	175	
	Dark coniferous forests	3.9	29.62	116	
	Small-leaved forests	2.5	23.07	58	
Wild boar	Broadleaved forests (low mountains)	1.4	57.75	81	803
	Coniferous-broadleaved forests (low mountains)	10.7	29.67	318	
	Dark coniferous forests	9.1	29.62	270	
	Small-leaved forests	5.8	23.07	134	
Roe deer	Broadleaved forests (hills)	3.0	49.9	150	837
	Broadleaved forests (low mountains)	5.0	57.75	289	
	Coniferous-broadleaved forests (low mountains)	7.3	29.67	217	
	Dark coniferous forests	6.1	29.62	181	
Musk deer	Coniferous-broadleaved forests (low mountains)	5.9	29.67	175	319
	Dark coniferous forests	2.9	29.62	86	
	Small-leaved forests	2.5	23.07	58	
Sika deer	Broadleaved forests (hills)	44.9	49.9	2241	2899
	Broadleaved forests (low mountains)	11.4	57.75	658	

Medved. Census of game species especially ungulates in Medved hunting lease is not an easy task. Ungulate distributions throughout the area are not even and influenced by natural factors such as altitude, snow depth, distance from the coastline, different river basins and other factors. Uneven distribution of ungulates is caused by human impact, the proximity of Lazovsky Zapovednik, intensive use of feed plots, and poaching. Red deer have shifted distribution to mid-range mountain areas due to the expansion of sika deer numbers. To survey ungulate populations two areas with highest ungulate densities were selected where feed plots are situated (Prokhladny creek basin and part of Peschanka creek basin) and the territory adjacent to Lazovsky Zapovednik beyond Glazkovka village (upper Lagunnaya, Glazkovka and Osinovaya creek basins). Survey area did not include bare mountain tops, clearings or agricultural fields. Total area of northern part of red deer range was 32,722 thousand ha, total area of conifer-broadleaved forests - 15,209 thousand ha (conifer-broadleaved forests combined with fir-spruce forests), total area of broadleaved forests was 13,394 ha. Total area where intensive feed plots are located (except for valley forests and agricultural areas) was 11,334 ha. The area adjacent to Lazovsky Zapovednik contains 9,114 ha of conifer-broadleaved and broadleaved forests. Mosaic distribution of conifer-broadleaved forests in this area and rarity of conifer forests allow extrapolation of the data to the total area of the census unit without differentiation between different community types.

The numbers of game species estimated for hunting lease is given in Table V.3.

Amur tigers in Medved Hunting Lease

The Amur tiger is the most significant predator among rare animals inhabiting Medved Hunting Lease. The Amur tiger is not rare in this area and occupies the entire territory of hunting lease from the Sikhote-Alin Range to the coast. Coniferous-broadleaved and broadleaved forests in hilly terrain, low mountains and middle mountains with high densities of ungulates are preferred tiger habitat.

Table V.3. Density and numbers of main game species in Medved Hunting Lease in 2004.

Species	Habitat type	Density, individuals/ thousand ha	Size of habitat type, thousand ha	Number of individuals per habitat type	Total number of individuals
Sable	Coniferous-broadleaved forests	7.8	37.02	289	454
	Broadleaved forests	3.1	53.19	165	
Siberian weasel	Broadleaved forests	0.6	53.19	32	32
Red deer Northern unit	Coniferous-broadleaved forests	11	15.21	167	522
	Broadleaved forests	14	13.39	187	
Red deer near feed plots	Broadleaved forests	6	11.33	68	
Red deer, Southern unit	Coniferous-broadleaved and broadleaved forests	11	9.11	100	
Wild boar	Broadleaved forests	1	39.35	39	156
Wild boar, near feed plots	Broadleaved forests	7.95	11.33	90	
Wild boar, Southern unit	Coniferous-broadleaved and broadleaved forests	3	9.11	27	
Roe deer	Coniferous-broadleaved forests	2	30.42	61	1045
	Broadleaved forests	6	39.35	236	
Roe deer near feed plots	Broadleaved forests	36.82	11.33	417	
Roe deer, Southern unit	Coniferous-broadleaved and broadleaved forests	6	9.11	55	
Musk deer	Coniferous-broadleaved	2	9.0	18	18
Sika deer	Coniferous-broadleaved	9	30.42	274	2275
	Broadleaved forests	6	39.35	236	
Sika deer near feedplots	Broadleaved forests	87.45	11.33	991	
Sika deer, Southern unit	Coniferous-broadleaved and broadleaved forests	85	9.11	774	
Brown bear		0.16	103.7	16	16
Himalayan bear		0.13	103.7	14	14

High tiger densities are observed in Prokhladnaya and Peschanka river basins and adjacent areas where ungulates are provided with supplementary forage.

The number of tigers in 2004 in Medved hunting lease was 6-7 individuals, including 1-2 males, 3 females and 2 tigers of unknown sex and age. Hunting lease staff confirms that 6-7 tigers inhabit the territory of Medved hunting lease, therefore estimates of tiger specialists and lease staff coincide.

According to Yudakov and Nikolaev (1987), Kucherenko (1993) and Pikunov (1981) one Amur tiger kills 60-70 big ungulates each year. According to monitoring data at least 7 tigers inhabit the territory of this hunting lease, therefore they will kill 420-490 large ungulates each year. If two roe deer will be considered as on big animal then the annual harvestable surplus for carnivores on ungulate populations in hunting lease is (50+110+40+400) 600 individuals. If tigers kill 490 ungulates then other predators and poachers can kill only 110 individuals. If tiger numbers increase by two individuals, which would kill another 140 ungulates, then ungulate populations will decrease. Table V.3. shows that there is only a reserve of 155 sika deer, which is presently illegal to hunt.

Far Eastern leopard in "Medved" Hunting Lease

No leopard tracks have been reported in the northeastern part of Lazovsky Raion since the 1970s. The last leopard tracks observed near Glazkovka village were reported in "Letopis prirody" of Lazovsky Zapovednik. Authors of "Lazovsky Zapovednik" monograph suggest that leopard tracks became rare when tiger numbers increased. According to D. Mezentsev (1997) four leopard encounters were observed in this hunting lease in the 1980s and two encounters in the 1990s. During field research in the hunting lease felid tracks (width of combined track is 7 cm) were found. It was believed that the tracks were left by dirty paws of a Far Eastern leopard on ice.

APPENDIX VI. DISEASE MANAGEMENT PROGRAM

John Lewis

INTRODUCTION

The comprehensive study and management of infectious and non-infectious diseases are vital components in both the protection of the existing population of leopards in Southwest Primorsky Krai and the sustainable reintroduction of a second population into former leopard habitat. Our overall goal is to develop a flexible disease risk management strategy that identifies significant disease threats, and provides guidelines to monitor and mitigate these in the existing wild leopard population, reintroduced leopards and other wildlife species in Primorsky Krai.

OBJECTIVES

1. To evaluate the health status of the existing Far Eastern leopard population and identify any disease issues that may threaten their survival.
2. To identify any significant diseases in wildlife, agricultural or domestic species in the proposed release zone that may pose a threat to reintroduced leopards.
3. To avoid the introduction of any novel disease into wildlife, agricultural or domestic species of Primorsky Krai during attempts to reintroduce leopards into the area from captive stock. This objective will be achieved by thorough screening of any captive Far Eastern leopards that become involved in the project.
4. To provide ongoing monitoring of the health of the existing leopard population in Southwest Primorsky Krai and that of any reintroduced leopards in the southern Sikhote-Alin Mountains throughout the life of the project.
5. To develop and maintain a flexible disease risk management strategy for the Far Eastern leopard.

HEALTH STATUS OF EXISTING FAR EASTERN LEOPARD POPULATION

A. Theoretical disease risk assessment

In order to focus testing effort on the infectious agents most likely to present significant problems to the wild leopard population, a theoretical disease risk assessment (DRA) was carried out by John Lewis using “paired ranking” and other techniques (see Table VI.1 below). Refinement of this assessment will be ongoing in the light of further disease screening data from wild leopards, other large carnivores and prey species in the area.

In all disease screening efforts it will be our policy to focus the most effort on the high risk infectious disease agents and other potentially significant non-infectious diseases (such as abnormalities attributable to inbreeding or environmental pollution for example). Finances available for veterinary investigations will inevitably be limited and it is essential that we use what money is available to greatest effect. However, it should also be standard policy to take sufficient samples to allow future investigation of lower risk diseases or newly emerging diseases as and when further resources become available.

Table VI.1 – Important infectious agents & diseases based on a theoretical DRA

DISEASE/AGENT	RANKING (ORDER OF POTENTIAL IMPACT)
Feline Immnodeficiency Virus (FIV)	1
Feline leukemia/sarcoma virus (FeLV)	2
Rabies	3
Canine Distemper Virus (CDV)	4
Tuberculosis (M.bovis)	5
Pseudorabies (Aujesky's disease)	6
Feline Calicivirus (FCV)	Equal 7
Feline Herpes Virus (= Feline Rhinotracheitis Virus) (FHV)	Equal 7
Feline Infectious Peritonitis (FIP or FCoV)	Equal 8
Sarcoptic Mange	Equal 8
Yersinia pestis	9
Dirofilaria immitis (Heartworm)	10
Feline Parvovirus (= Feline panleukopenia) (FPV)	11
Chlamydophila felis	Equal 12
Avian influenza (High Pathogenicity)	Equal 12
Francisella tularensis	13
Haemobartonella (FIA)	14
Anthrax	15
Ancylostoma	16
Bordetella	Equal 17
Isospora	Equal 17
Babesia	18

B. Clinical investigations of wild leopards

Since October 2006 a joint team from the Russian Academy of Science's Institute of Biology and Soils (IBS) and WCS-Russia has been trapping wild leopards and tiger in Southwest Primorsky Krai for the purposes of medical evaluation. Four (2 males, 2 females) wild leopards in the Nadezhdinsky Raion have been caught on 7 occasions between October 2006 and November 2008. Details are given in table VI.2. Immobilization in all cases was achieved using a combination of tiletamine and zolazepam ("Zoletil"), supplemented with isoflurane gas to prolong and deepen anesthesia as required. No significant problems arose attributable to anesthesia.

Table VI.2: Leopards caught between October 2006 and November 2008

Leopard identity	Gender	Date caught	Location
Pp01	Male	29-Oct-06	UTM 708131 x 4817804
		27-Apr-07	Nezhinskoye Hunting Lease
Pp02	Male	02-Nov-06	UTM 705078 x 4819780
		18-Oct-07	UTM 705887 x 4814078
		08-Oct-08	UTM 700675 x 4812468
Pp04	Female	15-Oct-07	UTM 710207 x 4813458
Pp05	Female	18-Oct-08	UTM 700675 x 4812468

Each animal was examined by an experienced large cat clinician and biosamples taken for disease screening and banking. Tests have been carried out for the carriage of, and/or exposure to, a wide panel of diseases.

The physical health of the leopards was judged as good, and the degree of dental disease consistent with other large wild felids. No physical evidence of congenital or genetic defects was found, nor have significant viral infections yet been detected. However, heart murmurs (*abnormal sounds produced within the heart or great vessels & detected by use of a stethoscope*) were detected in all four animals. Cardiac murmurs in anaesthetized animals can be caused by functional, positional or physiological factors unrelated to heart disease, and as such are not of major concern. In contrast, pathological murmurs may result from congenital lesions or heart disease occurring during an individual's life and these may signify potentially serious health issues. The findings in wild leopards so far are not straightforward to interpret, nor is detailed investigation easy under field conditions. Crucially, information from one leopard caught on 3 occasions (Pp02) demonstrated that during successive anesthetic episodes using similar drugs an individual leopard can have no detectable murmur, a loud and persistent murmur, or even a detectable murmur at the beginning of the anesthetic that rapidly diminishes to zero before the examination is concluded. Although complacency is clearly inappropriate, this information tends to argue against the presence of serious congenital or structural defects and suggests that functional or physiological factors may be involved. Murmurs caused by major structural effects in the heart – including some of the most important congenital abnormalities – tend to be far more consistent.

C. Laboratory investigations of wild leopards – viruses & bacteria

Between June 1993 and April 1997 seven leopards were caught for the purposes of radiocollaring by a team from the IBSS and WCS-Russia. Although no virological tests were conducted on 1 animal, in the remaining six leopards no evidence of infection with FIV or FeLV was found; 4 animals showed evidence of exposure to FPV, 2 animals showed evidence of exposure to CDV and 3 animals showed evidence of exposure to a Feline Coronavirus. Information from WCS Russia)

Using a panel of tests in the 4 leopards caught between October 2006 and November 2008 no evidence was found of infection with, or exposure to, Bartonella, Canine Distemper Virus (CDV), Feline Immunodeficiency Virus (FIV), Feline Leukaemia Virus (FeLV), Feline Calicivirus (FCV), Feline Herpes Virus (FHV), Feline Chlamydophila, Mycoplasma felis or Rabies. Evidence of exposure to toxoplasmosis (positive antibody titer) was found in 2/4 leopards, to Feline Coronaviruses in 1/4 leopards, and to Feline Parvovirus (FPV) in 2/4 leopards.

D. Laboratory investigations of wild leopards – parasites

The level of endo- and ecto-parasitism has so far been found to be low. The occasional *Ixodes persculatus* tick was observed on 2 of 4 leopards. Low numbers of hookworm eggs (*Ancylostoma spp)* were found in the feces of one leopard. (Hookworm eggs have also been identified in the feces of tiger in this area as well).

Tests have also been carried out for blood parasites in the leopards. No antigenic or hematological evidence of the heartworm *Dirofilaria* or *Mycoplasma haemominutum* was found in any. *Mycoplasma haemofelis* and *Hepatozoan spp* was identified in 1 of 4 leopards.

E. Laboratory investigations of wild leopards – other

Haematological investigations have shown white cell count patterns consistent with a degree of stress (assumed to be caused by the process of trapping) with haemoglobin counts consistent with those found in captive Far Eastern leopards.

Although Uphyrkina et al (2002) reported a marked depletion of population genetic diversity in the free ranging Far Eastern leopard compared to other leopard subspecies, their work was based on seven animals caught between 1993 and 1996, and further sampling from current capture activities may add useful data. Appropriate samples were taken from the 4 leopards caught since October 2006 and are currently held at IBS and WCS in Russia.

Other information concerning the genetic diversity of the wild leopard population could be gained by a study of the heterogeneity of the MHC Class II gene array. Dr Lorna Kennedy of the Center for Integrated Genomic Medical Research (CIGMR), Manchester, UK has already started to conduct such studies on the captive European Far Eastern leopard population and is willing to extend her work to include wild leopards, subject to the appropriate permits being issued for sample export from Russia.

In the opinion of all the veterinarians involved with this project a degree of inbreeding in the free living Far Eastern leopard population is likely given the size of the population, although the precise impact on population health has yet to be determined.

F. Laboratory investigations of other species

As an adjunct to the direct screening of wild leopards, samples collected from other species caught in the same areas can be tested for a range of infectious and non-infectious diseases that may affect leopards. This would allow construction of a more comprehensive picture of potential disease risks currently faced by the leopards without having to increase the number of leopards caught. Attention should be focused on leopard prey species and other carnivores that share the habitat.

At present there is no formal plan or funding to conduct such a screening program. However, samples taken from non-leopard species caught by the IBS – WCS-Russia team are being stored for future analysis as and when funding becomes available.

Interestingly, previous disease screening of over 40 tigers caught in the Russian Far East revealed no evidence of FeLV or FIV infection, widespread exposure to FPV (70%) and toxoplasmosis (63%) and a significant level of exposure to CDV (15%) (Goodrich et al. 2005).

G. Necropsies of dead Far Eastern leopards

The post mortem examination of dead leopards, even if the death occurred sometime before examination, is an important tool in wildlife health surveillance. In addition to the studies in live leopards caught by IBS and WCS-Russia, one dead female leopard was presented to the team by Inspection Tiger staff in April 2007. At necropsy no gross physical abnormalities were detected and the cause of death was clearly identified as a poacher's bullet followed by blunt trauma to the head. Notably, no lesions were seen in the heart or great vessels.

Another female leopard was presented for necropsy to the Primorskaya State Academy of Agriculture (PSAA), Ussurisk, in February 2009. Cause of death in this case was impossible to establish definitively as the carcass was markedly decomposed and damaged by scavengers. However, no evidence of genetic or congenital abnormalities were seen in the remains.

H. Leopard samples stored in Russia

Although it has been possible to carry out a limited number of tests on wild leopards so far, it is the project's intention to investigate a far wider range of potential infectious agents which may or may not be present in the leopards, or to which the leopards have been exposed. To this end, samples of serum, plasma, hair, and EDTA blood have been collected from each leopard, and are currently held in liquid nitrogen at both the offices of the IBS and WCS-Russia in Vladivostok. Ectoparasites and blood smears from each animal have also been stored.

I. Summary

It cannot be over-emphasized that to date only an extremely small number of wild leopards have been investigated, and therefore any conclusions drawn from their veterinary screening can only be provisional at best. Furthermore only a relatively limited range of tests have been applied to each animal. If we are to understand the infectious and non-infectious threats to the existing leopard population it is crucial that these studies continue, although given the current wild population size it will never be possible to sample a large number of leopards. It has never been the intention of the team to catch any individual leopard more than once, but ironically animals that are recaptured are especially valuable to this work. By repeating veterinary investigations on individual animals it is possible to construct partial life histories (with respect to disease) and already data gathered from Pp02 has shed some light on the significance of cardiac murmurs and the development of dental disease.

The leopards caught between October 2006 and November 2008 were in good general condition, showed no evidence of suffering from or being exposed to major feline respiratory pathogens, but were found to have been exposed to toxoplasmosis, parvoviruses and feline coronoviruses. No cases of FIV or FeLV were detected. Parasite loads in these cats were judged insignificant. Heart murmurs were heard in all four leopards, but the significance of this finding is still under investigation. No evidence of serious congenital or genetic defects has yet been found.

SIGNIFICANT DISEASE RISKS IN PROPOSED RELEASE ZONE

If captive-bred leopards are to be reintroduced into Southern Sikhote-Alin, it is essential that surveys are carried out in the proposed release zone to assess the disease risks to which released animals would be exposed. There would be no value in releasing leopard into an area in which, for example, tuberculosis was a common disease in prey species. Although a healthy tiger population exists in Lazovsky Zapovednik and surrounding territories where initial reintroduction attempts are proposed, that is insufficient evidence of a lack of disease that could affect leopards as the prey bases of leopard and tiger are slightly different.

As part of the Zoological Society of London’s (ZSL) Amur Leopard and Wildlife Health Project (ALWHP), a sampling and testing strategy was designed for the Lazovsky Zapovednik and surrounding area, and sampling of wildlife species and domestic animals was started in autumn 2007 by Dr Linda Kerley and Russian veterinarian Dr Mikhail Goncharuk. The focus of this sampling effort was on potential leopard prey species including red deer, roe deer, sika deer, wild boar, raccoon dog, red fox, badger, Far Eastern wild cat, Manchurian hare, Siberian chipmunk, sable and small rodents, and domestic dogs and cats in the area. Considerable attention was focused on sampling domestic species such as feral and pet dogs outside the reserve as they are not only capable of carrying infectious diseases that may affect leopard, but also of concentrating or amplifying risks. Examples of the latter include rabies and canine distemper. In both cases leopards alone are unlikely to sustain a disease outbreak, but a dog population could easily do so. In addition to infectious disease surveying it is desirable that the level of environmental pollutants (including lead, mercury, arsenic & total PCB load) is assessed in prey species. This is likely to be an expensive exercise but it is possible that suitable assays are available in laboratories within the Russian Federation.

Preliminary results from the ALWHP survey suggest that FIV, FeLV and heartworm are not common in the area. However, sarcoptic mange was confirmed in raccoon dogs – a significant finding as mange is a condition that could affect reintroduced leopards. Further results remain largely outstanding while appropriate diagnostic laboratories are identified in the Russian Federation. If that proves impossible or impractical licenses will be sought to allow export of the samples for testing elsewhere.

In addition to direct surveillance by sampling prey species etc, information about disease in the proposed release area is also being sought from regional state veterinarians, veterinarians in private practice, veterinarians working with deer farms, and hospital and abattoir records. These are invaluable sources of information and it is essential for the future that such agencies are fully engaged with, and supportive of, any leopard reintroduction attempt. Dr Goncharuk has spent considerable time recently developing a network of veterinary colleagues with relevant expertise. Through these channels it has been possible to discover that rabies, tuberculosis and leptospirosis have not been identified by the State veterinary service in the Lazovsky region during the past 10 years, and that small animal clinicians frequently see presumed cases of CDV in domestic dogs.

The Russian veterinary literature is another important potential source of information in the assessment of the disease status of the proposed reintroduction area. Despite there being very few contemporary accounts of disease in either wildlife or domestic pets in the Lazo region there are published accounts of sporadic rabies outbreaks in raccoon dogs in the Russian Far East – information which should be taken into account when designing disease risk strategy for reintroduced leopards.

HEALTH STATUS OF CAPTIVE FAR EASTERN LEOPARDS

It should be axiomatic that only the offspring of healthy captive leopards should be released during any attempt to reintroduce the Far Eastern leopard into its former range. Not only is this a matter of good reintroduction practice, but it is especially important for this particular project as the introduction of any feline disease into the region could jeopardize the future of both the wild Amur tiger and the existing Far Eastern leopard populations. Rigorous efforts must be made to ensure that we not only choose clinically healthy leopards for the purpose, but that we can also be confident that any such animals are not carrying undesirable infectious pathogens or deleterious genes.

A. Disease screening of captive leopards

Considerable progress has been made in the past few years in health screening the captive Far Eastern leopard population throughout European zoos. This is of course necessary to maintain a healthy captive population within the European breeding program (EEP), but the level of health screening for animals that are candidates for involvement in the reintroduction program (by virtue of their genetic suitability) must be of an even higher standard. As a result a screening protocol has been drafted by the veterinary advisor to the EEP (Dr John Lewis) and distributed to member collections. It is intended that no candidate leopard will be transferred to the Russian Far East until all tests within the protocol have been applied with a satisfactory result. The North American Far Eastern leopard breeding program (or SSP) is an earlier stage of its development, but Dr Doug Armstrong of the Henry Doorly Zoo, Omaha, has agreed to act as its unofficial veterinary advisor. The EEP screening protocol will be discussed between Drs Armstrong and Lewis to ensure a uniform approach for both the EEP an SSP.

In general terms screening efforts are directed at establishing freedom from high risk infectious agents (see above), physical abnormalities, known genetic abnormalities and specific problems that have arisen in the captive leopard population. Furthermore attempts are made to establish the degree of resistance to specified feline infectious diseases. To date, 36 cats within the EEP have been comprehensively or partially screened. No cases of FIV, FeLV, heartworm or Feline Infectious Anaemia (FIA) have yet been identified. (Details of the screening protocol are available on request).

In addition to screening captive leopards that are to be transferred to the reintroduction area for the purposes of breeding, it is planned that any offspring produced *in situ* will undergo a through physical examination and further viral testing before release. Whether or not these animals will be vaccinated against the common feline pathogens at this time will depend, at least in part, on the results of disease profiling of wild leopards and of disease survey activities in the release area. Breeding adults would have been vaccinated against some common feline infectious diseases as part of their management within the EEP, and it is likely that primary vaccination of offspring to be released would be advantageous.

The process of screening leopards in Russian zoos offers unique educational opportunities for veterinary students from the Russian Far East. For example, when 3 leopards at the Novosibirsk Zoo and 3 at the Moscow Zoo were assessed in June 2007 by an international team headed by Dr Lewis, veterinary students from Ussurisk were involved throughout. All transport and living costs for the students were met by ZSL.

B. Heart murmurs in captive leopards

Heart murmurs have not only been detected in wild Far Eastern leopards but also in a significant number of captive EEP leopards examined by Dr Lewis - and in captive leopards of other subspecies. Understanding the cause of murmurs in wild leopards may be facilitated by in depth clinical investigations in their captive counterparts – investigations which are impractical in free living wild animals. To date, detailed electrocardiographic and echocardiographic investigations have been conducted in 10 affected captive leopards in the UK. Murmurs in these animals were found to be a result of relatively minor regurgitation of blood through the right and/or left atrio-ventricular valves, or dynamic outflow tract obstructions – the latter being a direct consequence of an anaesthetized animal’s position. At present there appears no evidence of significant cardiac pathology resulting from congenital or genetic defects. Similar findings have now been reported from Copenhagen, Omaha and Minnesota zoos where leopards have been investigated in a similar manner. These studies are continuing – both in anaesthetized leopards and more recently in trained, conscious leopards in an attempt to understand the impact of anesthesia. Results from these studies will be published in the near future.

Note: No anesthetic complications attributable to abnormal cardiac function have been experienced during the examination of any of the wild or captive leopards examined so far.

C. Far Eastern Leopard Veterinary Database

Funded by Wildlife Vets International (WVI), progress towards developing a comprehensive database of veterinary information on captive and wild Far Eastern leopards has been considerable. Data fields of basic animal data, clinical matters, disease screening, routine clinical pathology, reproductive data and investigations, cardiac investigations, vaccinations, haematology and serum biochemistry profiles, necropsy findings and biosamples available for further study have been included so far. All original test results, necropsy reports, relevant pictures, cardiac ECG and sound recordings, etc are embedded in the database as pdf’s. Information entered is moderated by Dr John Lewis to ensure consistency of quality and definition.

To date, data from approximately 300 cats (including 5 wild leopards) has been entered. Once data from all EEP leopards has been included and remaining software issues resolved, the database will be available for research purposes. For a wide range of students this process should be relatively simple given that the Microsoft Access program has been used thereby facilitating novel query design.

D. Biosample bank

A centralised bank of biosamples taken from captive Far Eastern leopards throughout the EEP has been established in the UK to facilitate future research. Samples stored in liquid nitrogen include serum, plasma, EDTA blood, urine, and anal gland material. Tissue samples from necropsied leopards are held in formal saline, and hair samples sealed in containers at room temperature.

E. Miscellaneous studies in captive leopards

Not only are leopards within the EEP and North American breeding programs a potential source of animals for reintroduction purposes, but they also represent a valuable research population through which it may be possible to answer questions germane to the reintroduction process. As an example of this potential a project is already underway in the UK to conduct a simple investigation into how captive Far Eastern leopards react to the inevitable stress of moving between facilities. Measuring faecal cortisol metabolite output in leopards before, during and after a move between collections within the EEP should allow us to determine the length and severity of any clinically significant stress experienced. This will provide valuable information for the management of animals in any captive facility established in the reintroduction area.

ONGOING HEALTH MONITORING OF FREE LIVING FAR EASTERN LEOPARDS

If the Far Eastern leopard reintroduction program is to be a success in the long term, ongoing disease monitoring – especially in prey species and domestic carnivores – will be essential. It could be argued that the establishment of an apparently healthy leopard population demonstrable by remote techniques such as camera trapping and standard surveying constituted sufficient evidence of the absence of disease threats to the leopard. However, it would be preferable to take a more proactive approach to allow wildlife managers to monitor and react to changing disease patterns (due to emerging infectious diseases, epidemics etc) in leopard habitat before these posed a significant threat.

Direct health monitoring of existing leopard populations in Southwest Primorsky Krai and released cats in the southern Sikhote-Alin Mountains can be carried out opportunistically as and when animals are caught for any purpose. However, due to the low numbers of animals likely to be involved, it is highly doubtful that this alone would be successful in providing adequate information on changing disease patterns in the area.

A more rigorous approach would be to carry out regular exercises (say every 2-3 years) to assess the disease status of targeted wildlife, agricultural and domestic species in areas containing reintroduced (and existing) leopards through sampling representative numbers of animals and liaison with local state veterinarians. Ideally, such a program would be the responsibility of the new Wildlife Health Monitoring Unit (WHMU) recently established at the PSAA in Ussurisk, working in concert with state veterinarians responsible for the appropriate Raions (Lazovsky, Partizansky, and Olginsky) and the local hunting community. Not only would this approach give a focused purpose to the WHMU and perform an essential role in wildlife conservation in the RFE, but it would also generate considerable educational, training and research opportunities for the next generation of local Russian wildlife vets. That said, funding such a program remains problematic. Given adequate support, it is hoped that the WHMU at Ussurisk can become the local centre of excellence responsible for the post mortem examination of all dead Far Eastern leopards, for the collation and storage of materials collected from them, and for wildlife disease monitoring in the RFE generally.

One significant recent development is that a young Russian field veterinarian (Dr Mikhail Goncharuk) now works with Dr Lewis during field capture and medical assessment operations on the Far Eastern leopard. Dr Goncharuk has already worked with Dr Lewis during medical assessments of captive leopards in Russia and he is actively involved in ZSL'a project to assess the disease status of potential leopard prey species in the Lazo area. The long term future of veterinary involvement in conserving wild leopards in the Russian Far East absolutely requires that local expertise is developed, and the addition of Dr Goncharuk to the team is a valuable step forward.

DISEASE RISK MANAGEMENT STRATEGY

Decisions on the most appropriate ways to manage the Far Eastern leopard in the wild will clearly be based on a wide range of expert input, one component of which will be a Disease Risk Management Strategy (DRMS). The latter will be based on information gained from the activities detailed above, plus theoretical modeling of any significant disease threats identified. It is important that such a strategy is written and considered before any leopards are transferred from the captive population to the RFE.

The DRMS will inform wildlife and veterinary managers about the most significant current disease risks to existing and any reintroduced leopard populations and identify strategies to mitigate these risks. Management strategies for likely future infectious disease epidemics will be included to allow rapid response to such events. It is intended that the DRMS will be a living document subject to regular annual review in the light of accumulating veterinary data from the area and in order to drive this process plans will be included to guide future disease monitoring activities.

It should be noted that the DRMS will not suggest eliminating disease risks for the leopard, but policies to manage them, i.e. reduce risks to an acceptable level. In respect to any particular disease risk a variety of actions is possible from doing nothing to attempting eradication. Which action will eventually be taken depends on the predicted impact of disease in question, the feasibility as well as the veterinary and ecological implications of any management options, the cooperation of local state veterinary services and even legal and economic implications. Therefore, decisions on specific management strategies are likely to involve discussions with a wide range of stakeholders in each case.

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Considerable progress has been made over the past 3 years in assessing the health status of both free living and captive Far Eastern leopards, although further screening on retained samples should be carried out when resources allow. No major infectious diseases have been identified so far as affecting the wild or captive leopard populations. However, from consideration of the theoretical disease risk assessment and information gathered from the screening activities in the proposed release zone, several infectious diseases are recognized as potential threats to existing or reintroduced leopards – namely Canine Distemper Virus, rabies and sarcoptic mange. Precautions are also necessary to minimize the risk of serious feline infectious diseases being transferred from feral domestic cats to reintroduced leopards in Lazovsky Raion.

In the opinion of all the veterinarians involved with this project a degree of inbreeding in the free living Far Eastern leopard population is likely given the size of the population, although the precise impact on population health has yet to be determined. Studies to determine the impact of genetic impoverishment on immune function of wild and captive far Eastern leopards are ongoing. Such investigations may affect our choice of leopards to be transferred to the RFE prior to any reintroduction. Concern over the finding of heart murmurs in wild and captive leopards is warranted, although at present the evidence suggests that cardiac pathology or congenital disease is not responsible.

The development of the Wildlife Health Monitoring Unit in Ussurisk could provide the core for future wildlife disease monitoring in the RFE essential to the long term success of any reintroduction process.

The inclusion of all veterinary data from captive and wild leopards into a database will facilitate future population veterinary analysis and research – the latter being aided by the development of the biosample bank.

B. Recommendations

In advance of a formal DRMS being drafted the following recommendations are made to mitigate the impact of disease on free living Far Eastern leopards:

- Veterinary investigation of wild leopards should continue in order to expand our knowledge of the disease threats currently experienced by this population. Current tentative conclusions are based on a very low number of individuals.
- Veterinary investigation of the captive Far Eastern Leopard population should continue, focusing on those animals that are genetically suitable for reintroduction.
- Disease screening of prey & domestic species in the proposed release zone should become an ongoing process in the future under the aegis of the WHMU.
- The WHMU at Ussurisk should become the reference center for Far Eastern Leopard veterinary investigation in the future. The short term financial and technical support necessary to achieve this goal must not be underestimated.
- The development of a network of local interested veterinarians from the regional state veterinary service, private practice, deer farms, etc should be encouraged. A small core group has already been formed by Dr Irina Pavlovna Korotkova, head of the WHMU.
- Continued training of local veterinarians in modern conservation medicine practices is essential.
- All hunting leases in Southwest Primorye should introduce a ban on the use of dogs in order to reduce the risk of introducing potentially fatal infections to the existing leopard population.
- Attempts must be made to ensure that effective vaccination programs are in place to prevent infectious disease outbreaks in domestic cats and dogs in the Lazo region (including feral animals). The status of any existing vaccine program is unclear. Diseases to be included are FeLV, FCV, FHV, Feline Chlamydophilosis, FPV and rabies in cats, and CDV, leptospirosis, Canine Parvovirus and rabies in dogs. Any such vaccination program should be in place long before leopards are reintroduced.
- The prevalence and distribution of sarcoptic mange in raccoon dogs in the Lazo region must be investigated further and documented.

APPENDIX VII. EDUCATION AND PUBLIC RELATIONS PROGRAM IN SUPPORT OF REINTRODUCTION

V. Solkin and S. Bereznyuk

An education and public relation program in support of the reintroduction program is not a luxury, but an essential component of the overall plan. When comes time to release leopards, we will not only need to prepare the leopards, but also the local people should be prepared so that they will welcome the leopards or at least tolerate them.

In order to achieve this goal the education and public relation components of the reintroduction program should:

1. Be well planned and coordinated.
2. Analysis (social surveys) should precede each major stage in order to determine the attitude and major social obstacles that the program needs to address among the main target groups.
3. Should make use of both traditional (meeting, distribution of printed materials, information via printed press) as well as modern audiovisual techniques.

We divide work with local human population into three stages.

Stage I

Inform local people about the program itself, the need for reintroduction, goals, actions, etc. When the local population has been informed we will perform a first social survey in order to define the attitudes and opinions of the main target groups. Further education actions will be designed based on the survey results.

It is important that this stage should be completed before the construction of a reintroduction center with breeding and release enclosures.

Stage II

Next we will launch an education and public relation campaign in support of the reintroduction in which we address negative opinions and attitudes that have been defined during the survey. Our aim will be to minimize negative expectations and promote positive ones. We will use existing methods that have proved effective in Far Eastern leopard campaigns in the Southwest Primorye as well as new ones.

It is important that the campaign should achieve success before release of the animals into the wild.

Stage III

Having analyzed changes in people's minds by means of a 2nd social survey we will, as needed adjust our campaign. When leopards have been transported to the center and have been released information on the individual leopards will form a major component of the campaign. Local people should no longer regard the leopards as anonymous strangers.

A process of engagement must be developed to get local people involved and supportive of the reintroduction program. This process should include:

1. Elaboration and methodical implementation of educational programs at kindergartens and schools;
2. Creation of a productive feedback system and exchange between reintroduction project personnel and main users of natural resources (hunting leases, farms);
3. Damage compensation resulting from livestock kills by both leopards and tigers and active promotion of this compensation scheme;
4. Patronage of individual leopards by schools, forestry units, hunting leases, and municipal administrations;
5. Extensive coverage of the reintroduction program in all media;
6. Expansion and shifts in area-focus of the education program will be based on the direction of leopard dispersals and the expansion of the range of the newly introduced population.

Table VII.1 Actions, results, timing and responsible organizations for an education program associated with reintroduction of Far Eastern leopards

Action	Mid-stage	Long-term result	Timing	Organization
1. Information campaign to inform local residents about reintroduction program	1. Scheduling, elaboration and launch of a joint audiovisual information set. 2. Distribution via media, eco-center of Lazovsky nature reserve, WWF visit-center, model hunting leases.	People have enough information to form an opinion and are ready to express it.	BEFORE building the center.	«Zov Taigi», WWF, Phoenix Fund, Lazovsky Nature Reserve Journalist club «Poslednyaya Sreda/Last Environment»
2. First social survey after first inform campaign	**1. Survey design** 2. Social survey 3. Analysis	**Communication actions are developed based on survey results**	By the time the Center has been built	WWF, Phoenix Fund, Lazovsky nature reserve, «Zov Taigi»
3. Communication work in support of the reintroduction program by local population	1. Scheduling, elaboration and edition of a joint audiovisual information set. 2. Improvement of Lazovsky nature reserve facilities. 2. Distribution of materials and activities at/via media, eco-center of Lazovsky nature reserve, "Zov Tigra/Call of the Tiger" National Park, WWF visit-center in	1. There is sufficient local support to believe that first released individual will run minimal risks of being harmed by people.	By the time the first leopards arrive at the Center.	«Zov Taigi», WWF, Phoenix Fund, Lazovsky nature reserve, Zov Tigra/Call of the Tiger" national park «Poslednyaya Sreda/Last Environment», Hunting Associations

	Chuguevka and model hunting leases. Mobile auditorium, contests etc.			“Medved (Bear)” and “Yuzhnaya Dolina (Southern Valley”) hunting leases
4. Study of changes in public opinion as a result of the campaign	**1. Survey design** 2. Social survey 3. Analysis	2. Livestock compensation scheme is launched. 3. System of local involvement in defense of is developed	By the moment of first releases.	WWF, Phoenix Fund, Lazovsky nature reserve, «Zov Taigi»
5. System of people’s involvement into events in leopard defense	1. Design and implementation of an educational program in kindergartens and secondary schools. 2. Development of system for distribution of information on individual leopards in center and after release	People have not only become accustomed to leopards presence but are proud of them	By the time of further releases	“Zov Taigi” WWF, Phoenix Fund, Lazovsky nature reserve, “Zov Tigra” national park, «Poslednyaya Sreda/Last Environment», Department of Culture

APPENDIX VIII. FAR EASTERN LEOPARD CONSERVATION BREEDING PROGRAMS FOR REINTRODUCTION

S. Christie and T. Arzhanova

Background

The breeding program for Far Eastern leopards in European and Russian zoos (the Far Eastern leopard EEP) is managed with the goal of producing maximum conservation support for the wild population. This is achieved through public education and awareness work, generation of useful data and skills, fundraising to finance field projects, and – last but not least – the conservation of a viable gene pool in case of the need to reintroduce the taxon to the wild.

In 2001 a meeting of relevant scientists and conservationists in the Russian Far East reached broad agreement that reintroduction of Far Eastern leopards, at a second site, from zoo stock was a necessary and feasible conservation action.

There was discussion at the meeting concerning the presence in the population of genetic contributions from "Founder 2", one of the original wild-caught leopards from which the present zoo population is descended. This leopard is thought, on the basis of morphological and molecular DNA evidence (Uphyrkina et al. 2002), to have originated not from the current range of the Far Eastern leopard but from neighboring subspecies *P.p. japonensis* in northern China. It is not possible to eliminate founder 2 from the zoo population and broad agreement has been reached that leopards containing contributions from founder 2 will be acceptable for release. The rationale for this decision is that the present captive population genetically reflects the common gene flow status of a contiguous range of Northeast Asian leopards that had occupied northern China, Korean and Russia a millennium ago. As such the robust and genetically diverse captive population provides a suitable candidate population – and really the only potential candidate population - for potential restoration of the wild population of *P. p. orientalis*. The EEP has adopted the strategy of aiming to reduce founder 2's genetic contributions without compromising the overall genetic diversity retained in the population. Working on this basis, leopards are being bred to produce offspring with between 10 and 20 percent founder 2 in their genetic makeup as breeding stock for release.

Status of the EEP July 2009

As of July 2009 the Far Eastern leopard EEP stood at 114 animals (67 males.47 females) in 50 institutions. This is a drop of 13 animals since July 2008, but this is due almost entirely to the death of a number of old leopards; the number of reproductively active animals in the population is stable over time at about 83. There are currently 30 leopards – 15 males and 15 females – suitable for use as breeding stock to produce young leopards for release in a reintroduction program. Breeding plans are slightly hampered at present by a sex ratio imbalance favouring males in the 0-2 age class, but this will even out over time. Essentially, the program is on course and there already exist young leopards suitable for breeding for reintroduction.

Status of the SSP (December 2008)

As of the end of 2008 the American Zoo Association (AZA) Far Eastern leopard Species Survival Plan (SSP) population included 48 animals in 30 institutions. There currently exist several individuals that may be suitable for use in the reintroduction program. For instance, as of September of 2009 the Minnesota Zoo houses 1 male and 2 female Amur leopards that are some of the most valuable in the population, and thus producing multiple litters from each female will serve to reduce the average population mean kinship.

APPENDIX IX. EEP SCREENING PROTOCOL FOR SELECTING BREEDING INDIVIDUALS FOR THE FAR EASTERN LEOPARD REINTRODUCTION PROGRAM

John Lewis

Selected individuals will be brought to a facility at the reintroduction site, and become part of a breeding pair to produce offspring that will be eventually released into the wild. Breeding pairs will be returned to their respective zoo facilities after their contribution to the reintroduction program. This protocol describes the veterinarian process for evaluating individuals prior to movement to the reintroduction facilities.

Essential tests to be carried out on all candidate leopards:

1. EVALUATE BEHAVIOUR, LOCOMOTION, VISUAL ACUITY, DEMEANOUR ETC BY OBSERVATION. Be aware that a leopard's behaviour can be influenced by the presence of the observer.

2. A THOROUGH CLINICAL EXAMINATION WILL BE CARRIED OUT UNDER GENERAL ANAESTHESIA AT 2 YEARS OR ABOVE.

   Particular attention should be focussed on:

   Oral health – dental & gingival condition, presence/absence of lingual papillomas etc.

   Head – skull deformities, under/overshot jaw, nasal discharges etc.

   External genitalia – check for normal vulvo-vaginal anatomy. Record presence/absence of penile spines, measure & record testicular dimensions.

   Testes - presence or absence of both testes
   (Cryptorchidism has been seen in at least one captive Far Eastern leopard)

   Cardiac evaluation by auscultation, ECG, echocardiography & thoracic radiography using standardized methods.
   (Pan-systolic heart murmurs have been detected in both wild and captive leopards – cause as yet undetermined)

   Limb conformation & joint mobility. (count toes!)
   (Congenital distortion of the radius & ulna has been seen in at least one litter of captive leopards)

   Ophthalmoscopic examination of eyes

   Otoscopic examination of ears

   Hernias – the presence of umbilical hernias would be of particular concern.

   Tail length – measure & record.
   (Brachyury has been recorded in 4 captive Far Eastern leopards)

3. HAEMATOLOGICAL TESTS ON EDTA BLOOD

   Hematological profile to include hematocrit (PCV), hemoglobin, RBC count, MCH, MCV, MCHC, WBC count & differential, & platelet count.

Blood smear for hemoparasites including Babesia spp & Haemobartonella
(air dried and fixed for 1 minute in methanol)

PCR tests on EDTA blood samples for Dirofilaria, Babesia spp & FeLV

4. SEROLOGICAL TESTS

Serum biochemistry profile to include total protein, albumin, globulin, urea, creatinine, alanine transaminase (ALT), alkaline phosphatise (AP), gamma glutamyl transferase (GGT), & total bilirubin.

Specific serological tests for:

Chlamydophila	Antibody titre
FIV	Antibody (using ELISA & Western Blotting)
FCV	Antibody titre
FHV	Antibody titre
FeLV	Antigen
CDV	Antibody titre
FPV	Antibody titre
FCoV	Antibody titre
Dirofilariasis	Antibody titre
Toxoplasmosis	IgG & IgM antibody titre

5. PARASITES

Ectoparasites should be collected into 70% ethanol for identification & storage.

A fresh faecal sample should be examined for endoparasites. For preservation 70% ethanol is advised.

6. FECAL MICROBIOLOGY

3 fresh faecal samples should be cultured for undesirable bacteria such as Salmonella and Campylobacter spp.

Faecal samples should also be submitted for FPV and FCoV PCR testing.

7. GENETICS

EDTA blood samples (or blood in TES medium) can be used for further genetic investigations to investigate the current degree of genetic diversity and heterogeneity of the MHC Class II gene complex in captive leopards.

8. RESPIRATORY PATHOGENS

A nasal swab should be submitted for Bordetella culture

Oropharyngeal & conjunctival swabs should be submitted for FCV, Chlamydophila & FHV PCR tests

Oropharyngeal swabs in virus transport medium should be submitted for FCV & FHV culture.

9. SAMPLE BANKING

The following biosamples should be taken and stored for each leopard:

Serum	20mls	Stored at below -70°C
Plasma	10mls	Stored at below -70°C
Hair (plucked)	1 vial	Can be stored at ambient temperatures
EDTA blood	5mls	Stored at below -20°C
	OR	
Blood in TES	5mls	Stored at below 4°C

Desirable tests to be carried out on candidate leopards where possible

1. ASSESSMENT OF THE REPRODUCTIVE TRACT BY ULTRASONOGRAPHY

   NB – staff from the Institute of Zoo and Wildlife in Berlin, Germany, have already conducted a number of ultrasonographic reproductive evaluations of male and female captive Far Eastern leopards within the EEP.

2. IN THE CASE OF MALES: SEMEN COLLECTION, ASSESSMENT & STORAGE IN LIQUID NITROGEN.

   NB – staff from the Institute of Zoo and Wildlife in Berlin, Germany, have already conducted such reproductive evaluations of male captive Far Eastern leopards within the EEP.

3. URINALYSIS

   Urinalysis should be carried out on fresh urine (preferably collected by catheterization). Parameters include macroscopic examination, microscopic examination of sediment, ph, SG, quantitative evaluation of urine protein & creatinine & urine culture.

APPENDIX X. DISCUSSION OF THE IUCN REINTRODUCTION GUIDELINES

Reintroduction, as defined by the IUCN Re-introduction Specialist Group, is “an attempt to establish a species, subspecies, or race in an area which was once part of its historical range, but from which it has become extinct”.

Reintroduction of large cats has proven difficult, and there are few examples of successful, well-organized attempts (see Nowell and Jackson 1995 for a review of reintroduction attempts). Major challenges must be met if such a program is to be successful. However, results of the Florida panther reintroduction program indicate that large cats can be successfully reintroduced to their former range (Belden and McCowan 1995). Reintroduction of Far Eastern leopards into southern Sikhote-Alin represents additional challenges because, although it is likely the best remaining habitat, this region represents the northern limits of the species range, where conditions were presumably marginal when the population went extinct there. In addition to the environmental and ecological challenges, introduction of carnivores, even into former range, usually faces strong local opposition. Finally, reintroductions using captive stock introduce an even greater suite of challenges to be overcome. Nonetheless, there are reasons to believe the environmental conditions have dramatically changed, in favor of leopards, that local opposition will not be as vocal as other parts of the world, and that use of captive individuals as a source population is possible.

Specifically, the following problems have been identified as key issues by the IUCN Reintroduction Specialists Group that must be addressed for a successful reintroduction:

1) **Cost**. Reintroduction, especially if coupled with raising captive animals for release, is a very expensive project that will require major long-term investment. In the case of the Far Eastern leopard, the high cost of a successful reintroduction program will be one of the greatest barriers to implementation of a program. However, given the present interest from conservation sponsors in Far Eastern leopard conservation it is reasonable to expect that sufficient funding can be secured, both from individual and organizational donors, and from the Russian government.

2) **Suitable habitat**. It must be demonstrated that suitable habitat exists where the population can be reintroduced to its original range. The Resource Selection Function analysis provides strong indications that suitable habitat does exist in southern Sikhote-Alin. Of course, such analyses are limited by the suite of parameters that can be measured and included in a modeling process. Nonetheless, the results of this analysis are encouraging.

3) **Adequate Protection**. For any large carnivore population, human-induced mortality is likely to be a principal factor determining the viability of a reintroduced population. To reduce the extent of illegal harvest, there must be an adequate protection scheme in place when the reintroduction program begins. Protection in the reintroduction core zone (Lazovsky Zapovednik) and adjacent areas is adequate and additional protection will be provided in the form of a mobile anti-poaching team before the first releases take place.

4) **Local opposition to reintroduction program**. Support from local citizens will be a key factor to successful reintroduction. Hunters see large carnivores as competition for the same prey base (ungulates and fur-bearers such as badgers and raccoon dogs), and are likely to be opposed to a reintroduction effort. Human persecution is a major cause of mortality of large carnivores, and is likely one of the major causes of death in the existing leopard population. The attitudes and opinions of local people will be assessed during

meetings with stakeholders - such as hunters - and through social surveys, and an effort will be made to address their main objections (see Appendix VII).

5) **Cause of extinction must be under**stood. If the cause of original extinction is poorly understood, it is difficult to identify what conditions are necessary for successful reintroduction. In the case of the Far Eastern leopard the causes of extinction in south Sikhote-Alin are not clearly defined, but were likely the combination of numerous factors, including low prey densities, deep snow winters, weak law enforcement, and direct persecution by hunters (see section 6.4) Evidence suggests global climate changes are moderating winters in the Russian Far East, ungulate densities (specifically sika deer) have greatly increased in number, and better protection is already partially in place. Greater law enforcement efforts and education campaigns will improve this aspect of the program as well.

6) **Identifying source animals for reintroduction**. For any introduction effort, source animals should have a similar genetic make-up as the original population, and there must be sufficient numbers of them to make the probability of success high. The EEP for Far Eastern leopards is actively managing its population to ensure suitable leopards are available in sufficient numbers.

7) **Livestock Depredation**. Owners of livestock may be opposed for fear of losses to valuable animals. It is well documented that leopards regularly take dogs and smaller domestic animals in existing range in Southwest Primorye (Pikunov and Korkishko 1992). A compensation program will be started help to alleviate the financial burden, but resentment, still a byproduct to a depredation event, will have to be addressed via an aggressive education campaign.

8) **Suitable release protocol**. Success of a reintroduction protocol will be largely dependent on the release protocol. The capacity of large cats to disperse long distances, and the relatively unfragmented landscape proposed as a reintroduction site, can result in a scattering of individuals, and no development of a well-defined population. The number of individuals released, and timing of release will be critical. One way to reduce dispersal distances is to release females first (who often will settle close to their natal home range (which in this case will be the breeding pens) and then release males. Since males are most likely to settle in areas where there are available females, males should also be less likely to disperse long distances from the release site.

9) **Disease Risks**. The source animals must be free of any diseases, and all efforts must be made to avoid exposure of released animals to vectors of disease during the reintroduction process. This is especially important for reintroduction of the Far Eastern leopard, because any feline disease could expose the majority of the Amur tiger population to an infectious disease, and threaten that species existence as well. A well designed disease risk management program is in place (Appendix VI).

10) **Post-Release Monitoring**. It will be important to monitor the release animals, through radio-telemetry, to study the process of movement and adaptation by individuals, investigation of mortality, determination of reproduction, and assessment of needs for habitat protection. It will be especially important to define criteria for success, and criteria for when intervention will be necessary (due to threat to human lives or resources, or threat to the animals themselves). The capacity to capture and radiocollar large felids exists in the Russian Far East due to the long term Russian-American Siberian Tiger Project, which has trained a number of people in capture techniques, as well as telemetry

studies. We have defined criteria for success in terms of numbers of individuals, and have survey methods that allow determination of population numbers. Interventions will be performed on individuals that develop close associations with humans or become repeat offenders in depredation events.

The issues described above were taken into account in the development of the reintroduction program for Far Eastern leopards and this program document addresses all issues.

APPENDIX XI. PREDICTING POTENTIAL HABITAT AND POPULATION SIZES FOR FAR EASTERN LEOPARD (*PANTHERA PARDUS ORIENTALIS*) REINTRODUCTION IN THE RUSSIAN FAR EAST.

Mark Hebblewhite and Dale Miquelle

The goal of this exercise was to develop a habitat model for Far Eastern leopards to help guide selection of release sites and determine the potential suitability of habitat for leopards in southern Sikhote-Alin. To achieve this goal, we used survey data from Southwest Primorsky Krai to build a resource selection function that could then be applied to southern Sikhote-Alin to predict where suitable habitat may exist. A resource selection function (RSF) is any function that is proportional to the probability of use of a resource unit, or geographical area, and RSF's have been used in the past to help guide recovery of endangered species by identifying habitat for restoration, recovery, and even introductions.

METHODS

Leopard snow track survey

We used data collected from 7 surveys of leopards in Southwest Primorye in the following years: 1997 (Pikunov et al. 1997), 1998 (Aramilev et al. 1998), 2000 (Pikunov et al. 2000, Aramilev et al. 2000), 2003 (Pikunov et al. 2003), 2005 (tiger survey) (Miquelle et al. 2006), and 2007 (Pikunov et al. 2008). Each of these surveys was conducted along routes positioning in Southwest Primorye to maximize probability of encountering leopard tracks. Each track identified by fieldworkers is represented in a GIS database as a point location. Each of these point locations of leopard tracks from these surveys acted as a representation of "leopard presence."

Ungulate abundance and distribution

As a primary food resource ungulates clearly play a defining role in determining where leopards can exist. Therefore, inclusion of some indication of prey density is vital for predicting suitability of habitat for leopards. Unfortunately, not all of the above surveys collected data on ungulate abundance, and more importantly, there was no consistent means to extrapolate relative ungulate density in the proposed release zone when using survey data collected only in Southwest Primorye. To alleviate this problem we used data from the 2005 tiger survey, which covered the entirety of Southwest Primorye as well as southern Sikhote-Alin. Track abundance of ungulates on survey routes was used as an indicator of presence of that species in a survey unit (Figure XI.1).

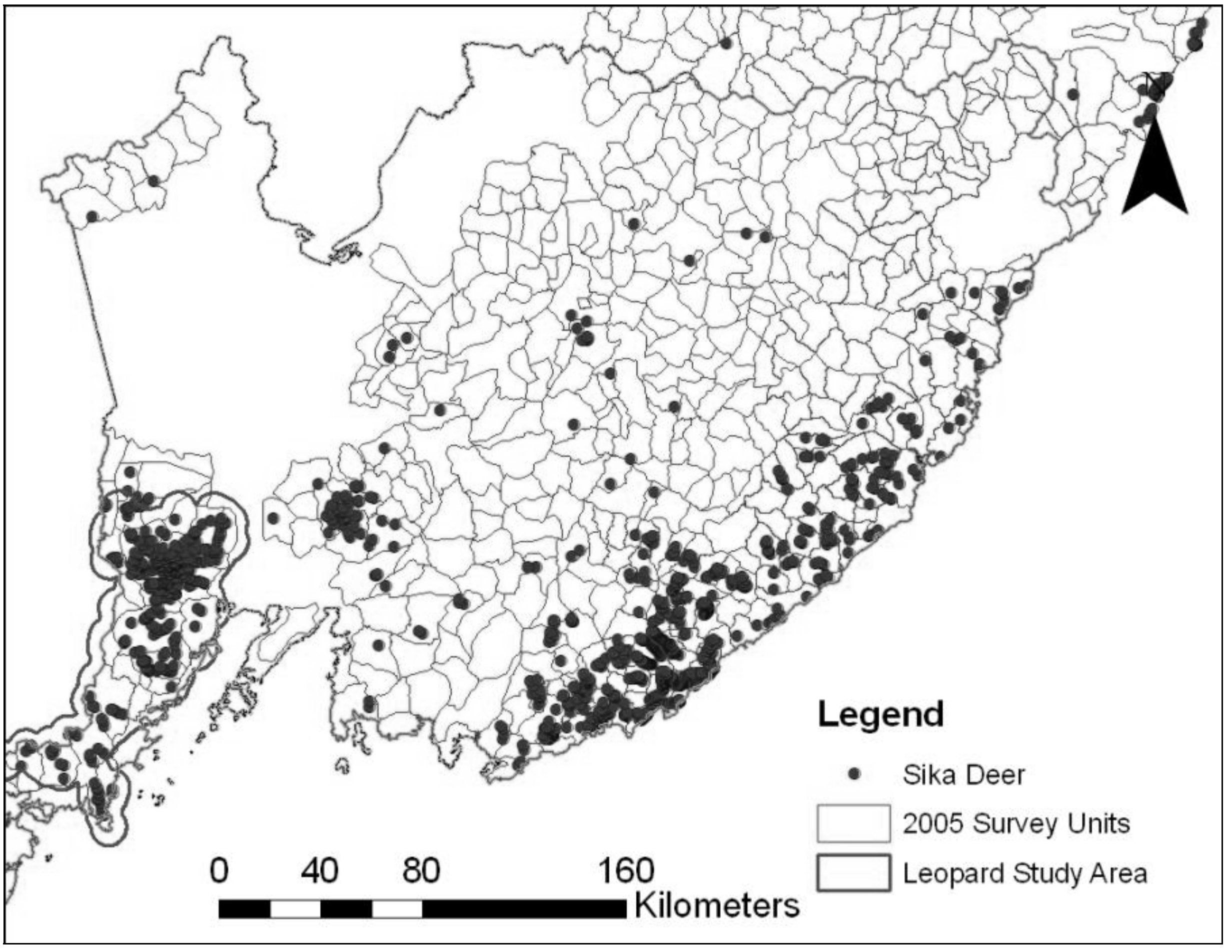


Figure XI.1. Sika deer sampling design in survey units in the southern Russian Far East, winter 2005, showing sampled units, Sika deer tracks, and the intensive Far Eastern Leopard study area.

Resource Selection Function modeling

We developed predictive habitat models for the Far Eastern leopard using a Resource Selection Function modeling framework (Manly 2002; Boyce and McDonald 1999). A RSF is any function that is proportional to the probability of use of a resource unit, or geographical area, and can be estimated using any number of designs where measures of species presence are compared to absence or available resources. Here, we used the leopard data collected on transects described above to estimate resource selection for Far Eastern leopards by comparing the spatial locations of Far Eastern leopard tracks to measures of what resources were available to Far Eastern leopards at two spatial scales in a "used-available" design. In "use-availability" designs, the true measure of prevalence is unknown because the number of available points is specified by the study design, yet the resultant relative probabilities remain quite useful for management ranking of habitat quality and the relative probability of occurrence (Keating and Cherry 2006, Johnson and Gillingham 2008). In our study design, used and available units were measured at the population level without information about individual Far Eastern leopard habitat selection.

We compared resource selection at the study area scale and a finer scale along the survey routes to help understand the effects of our sampling protocol, and to help identify important multi-scale processes in habitat selection (Johnson 1980, Boyce 2006). First, we defined a study area as the 99% kernel density home range estimator (KDE) surrounding all Far Eastern leopard tracks during survey years. We selected a bandwith for the KDE based on the mean estimated home range size for Far Eastern leopards (100 km^2 - a generalized estimate that is between the average home range size of males and females) using a bandwith of 5 km to conservatively include potentially occupied, but undetected habitats. This resulted in a ~ 6500 km^2 study area, within which we generated 0.5 random locations/km^2 (n=3500) to sample availability. Next, we investigated resource selection of Far Eastern leopard track locations (Table XI.2) to random locations along the survey routes by generating 1 random location/km survey route in each year. This finer-scale analysis allowed us to test for potential bias in survey route location by comparing random points along survey routes with random points at the study area scale. If there were no bias in survey route location, then we would predict no differences between survey route and study area availability.

We estimated the RSF by estimating the coefficients of the exponential approximation to the logistic discriminant function using logistic regression (Keating and Cherry 2006), excluding the intercept because of the use-available design following:

$$\hat{w}^*(x) = \exp(\beta_1 X_1 + \beta_2 X_2 + \ldots + \beta X) \qquad \text{(equation 1)}$$

where $\hat{w}(x)$ is the relative probability of selection as a function of covariates x_n, and $\boldsymbol{\beta X}$ is the vector of the coefficients (see habitat covariates below) estimated from fixed-effects logistic regression of used versus available (random) locations (Manly et al. 2002). Note that equation 1 yields a relative probability because the constant (the sampling fraction) is unknown.

We adopted a univariate and stepwise model selection approach following the approach of Hosmer and Lemeshow (2000). We first screened potential variables for collinearity using a cut-off of r=0.5 (Menard 2002), and then assessed univariate importance of each covariate, looking for linear, and non-linear effects using quadratics (x+x^2) (Hosmer and Lemeshow 2000). Once the best functional form of each covariate was determined, we included it in a best all-inclusive model for which we then conducted stepwise model selection (Hosmer and Lemeshow 2000). We tested for confounding variables by systematically removing and adding variables (Hosmer and Lemeshow 2000, Menard 2002). We tested for model goodness of fit using the linktest (Hosmer and Lemeshow 2000), likelihood ratio chi-square test, and residual diagnostics. We evaluated the predictive capacity of the top model using Nagelkerke's pseudo-r^2, logistic regression diagnostics such as ROC (receiver operating curves), and classification success (Hosmer and Lemeshow 2000). Most importantly, for habitat modeling with use-availability designs, we evaluated the predictive capacity of the RSF model using k-folds cross validation between the top model structure and each different year of Far Eastern leopard survey data as a measure of temporal variation in predictive capacity (Boyce et al. 2002).

Landscape Covariates

We used a combination of environmental and biotic spatial covariates to understand Far Eastern leopard resource selection, as described in Table XI.1. Environmental covariates included elevation, slope, aspect, and hillshade calculated from the Shuttle Radar Topography Mission (SRTM, Reuter et al. 2007) at an approximate 90m resolution using ARCGIS 9.2 Spatial Analyst. We also used remotely sensed measures of gross primary productivity and snow cover obtained from the Earth observation system MODIS (Moderate Resolution Imaging Spectroradiometer) satellite at intermediate (500, 1000m^2) resolution (Running 2004; Turner 2006). We used Gross primary productivity (GPP, the MOD17A2 product) as a measure of forage availability for ungulate prey of Far Eastern leopards, measured in KG/ha at 1 km^2 based on an algorithm that combines remote sensing vegetation indices (e.g., NDVI) with global daily meteorology data (See Running et al. 2004 for a general description and Heinsch 2003 for a detailed guide). We used an index of snow cover calculated as the percent (0-100) of the winter months during the winter 2004/05 (Nov 1 to Apr 30) that each 500m^2 MODIS satellite pixel was covered with snow based on the MOD10A snow cover product (e.g, Klein et al. 1998, Huete et al. 2002). Importantly, snow cover has been shown to be correlated with snow depth.

Biological covariates included a spatial vegetation community landcover model simplified from Ermoshin et al. (2004) that defines 12 vegetation community associations in the study area. The landcover model was developed from interpretation of Landsat satellite images. Vegetation communities were defined as: agricultural fields, grasslands/meadows, regenerating/young forests, burned or logged forests, shrub communities, oak forests, birch forests, riverine forests, larch forests, Korean pine forests, Spruce-fir forests, wetlands, and alpine communities (Table XI.1).

Ungulate habitat covariates. Finally, we used habitat models for three main prey species of Far Eastern leopards, sika deer, roe deer, and wild boar (in order of importance in the diet-Section 5.3). We developed ungulate RSF models from the Amur tiger survey conducted in winter 2005 (Miquelle et al. 2006). We employed a "used-unused" design in which survey units (averaging 131 km^2) acted as sampling units in which presence of an ungulate species' tracks during the simultaneous survey in 2005 was recorded as "used." A total of 11,473 km of survey routes were conducted in the extensive study area (Miquelle et al. 2006). We only used sample units with a minimum of 25 km/unit to ensure probability of detection = 1 (M. Hebblewhite, *unpublished data*), and treated units without tracks as unused. We then used the same covariates as for leopards at the scale of the sampling-unit using a logistic regression as:

$$\hat{w}(x) = \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta X) / (1 + \exp(\beta_0\ \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta X)) \qquad \text{(equation 2)}$$

where $\hat{w}(x)$ is the true probability of selection as a function of covariates as in equation 1, and β_0 is the intercept, which can be interpreted as the sampling fraction in used-unused designs (Manly et al. 2002). Because the sampling fraction is known, compared to equation 1, equation 2 yields a valid probability directly from logistic regression. Covariates were averaged using a moving window at the scale of the survey unit to ensure correspondence in scale between the dependent and independent variables in Eq. 2. We adopted the same modeling approach as for Far Eastern leopards above. We conducted model validation at two scales. First, within the "extensive" study area (southern Sikhote-Alin) using ungulate tracks collected throughout the winter 2005. Second, within the intensive study area (Southwest Primorye) using ungulate tracks collected during the Far Eastern leopard surveys in 2003 and 2007. This second analysis was especially important to test whether our extensive ungulate habitat models predicted observations of ungulates well within the intensive leopard area.

Table XI.1. Landscape habitat covariates used in the development of the Far Eastern Leopard Model for the Russian Far east, 1999-2008.

Landscape covariates	Source/Description	Citations
Elevation (m), Slope, Hillshade	Shuttle Radar Topography Mission, ~90 m resolution. Hillshade was calculated to make northerly aspects large numbers.	NASA/USGS, Reuter et al. (2007)
Net annual primary productivity (kg/ha)	MODIS satellite product MOD17A2; estimated maximum gross primary productivity for 2004, $1km^2$	Huete et al. (2002), Running et al. (2004), Turner et al. (2006)
Snow cover	MODIS satellite product MOD10A2; percentage of 16-day periods between Nov 1 and March 31st with snow cover, $500m^2$	Huete et al. (2002)
Vegetation communities (HABITAT)	Agricultural fields, grassland meadows, regenerating burned or logged forests, shrub communities, oak, birch, deciduous, larch, Korean pine, spruce-fir, wetland and alpine	
Distance to Zapovednik (km)	Distance in km from the edge of a Zapovednik	
Distance to roads (km)	Distance to paved and unpaved roads (not including forest roads)	
Roe Deer, Sika Deer and Wild boar	Probability of occurrence from RSPF models (see appendix)	Miquelle et al. (2006), Zhenxin; Hebblewhite

Delineating Potential Reintroduction Patches

We identified contiguous patches of potential Far Eastern Leopard habitat that could be suitable for reintroduction sites using the spatial predictions of the RSF model. First, we extrapolated the top leopard RSF model to the southern Primorye study area using ARCGIS 9.3.1 (ESRI Ltd, CA), predicting the relative probability of use for each pixel, *i*= 1….n. We estimated the cutpoint probability from the relative RSF model that captured 90% of the observed Far Eastern leopard tracks within the intensive study area. We chose to minimize misclassification of used sites (leopard tracks) over misclassification of available (pseudo-absence) sites because Far Eastern leopard tracks had lower classification success (see results). We used this cutpoint to reclassify predictions into either non-habitat (0 if w*(x) < cutpoint), or the relative probability if above the cutpoint. We then classified patches into small and large patches to identify potential movement patches and patches where >5 adult females might be able to persist based on the average fixed-kernel home range size of 100 km^2. We considered all patches >100 km^2 but <500 km^2 as small patches that might serve as "stepping stone" movement corridors (see connectivity mapping).

Evaluating Patch Connectivity

To identify potential leopard reintroduction patches that were more connected, we used resource selection functions combined with least cost path analysis to identify potential wildlife corridors following (Chektiewicz and Boyce 2006). Chektiewicz and Boyce (2009) evaluated connectivity for mountain lions and grizzly bears by calculating the relative costs of movements between patches of identified habitat by assuming that cost was inversely related to the probability of selection from an

RSF. Therefore, we used the cost path function in ARCGIS 9.3 to calculate the most likely corridors for movements between all leopard patches of habitat identified that were >100 km^2 under the same assumption.

Estimating Potential Leopard Population Size

We linked the RSF to estimated population size of Far Eastern leopards in Southwest Primorye (Table XI.2) to predict the potential number of Far Eastern Leopards that could occupy the total sum of large (>500km^2) patches of potential habitat. The theoretical details of the approach are summarized by Boyce and McDonald (1999), and Johnson and Seip (2008). We summed the total predicted relative probabilities for each leopard patch. Given the estimate for the number of leopards (*N*, Table XI.2) in the current range of leopards in Southwest Primorye, we then calculated the total predicted habitat required for each leopard and extrapolated the potential numbers of leopards possible in each potential habitat patch using the following equation:

$$\frac{\sum_{Current} \hat{w}(x)_i}{N_{Current}} = \frac{\sum_{Patch} \hat{w}(x)_i}{N_{Patch}} \qquad \text{(equation 2)}$$

where $N_{Current}$ is the Far Eastern leopard population estimate for Southwest Primorye Russia (known), $\sum_{Current} \hat{w}(x)_i$ is the sum of relative probabilities for the current population, and $\sum_j \hat{w}(x)_i$ is the summed predicted habitat probability for leopard patch *j*, and. N_{patch} is then simply solved by algebra.

The assumptions of this approach include a) the appropriate habitat covariates in the extrapolation region are the same, b) similar selection patterns will exist for spatial variables in the calibration and extrapolation areas, c) there is a similar landscape configuration of available spatial variables, and d) there exist similar relationships between population parameters and available habitat. Although the results should be used with caution, previous efforts using this RSF-population method have been successful (Mladenoff et al. 1999, Boyce and Waller 2003, Ciarniello et al. 2007), and results will at least offer a broad population goal to aim for in leopard reintroductions.

RESULTS

Snow Track Survey Results

We used data from n=467 tracks of adult leopards reported during 7 snow track surveys (Table XI.2). Expert assessments estimated anywhere from 22-44 individual adult leopards (mean = 30.8, SD = 6.53). In addition to these leopard surveys, we also collected an additional 137 tracks in 2005 during the Amur Tiger. We used these samples as an out-of-sample validation set for habitat models.

We also recorded tracks of sika deer, roe deer and wild boar to conduct model validation of the extensive ungulate habitat models applied within Southwest Primorye. In total, in the 2003 and 2007 leopard surveys 707 roe deer tracks, 1044 sika deer tracks, and 367 wild boar tracks were recorded.

Table XI.2 Surveys of leopards in Southwest Primorye. Track locations were used in developed a resource selection function to identify potential leopard habitat in southern Sikhote-Alin.

Year	# Leopard Tracks	Citation	Population Estimate
1997	48	Pikunov et al. 1997	25-31
1998	83	Aramilev et al 1998.	40-44
2000	43	Pikunov et al.2000	22-27
2000	42	Aramilev & Fomenko 2000	48-50
2003	197	Pikunov et al. 2003	28-30
2007	96	Pikunov et al.2008	25-34
Total	467	Average	30.8 (SD = 6.53)

Ungulate Prey Models

Ungulate used-unused RSF models showed consistent selection for Oak forests, regenerating forests, Korean pine-Broadleaved forests, and for areas further from roads and protected areas (Table XI.3). The three species differed slightly in selectivity coefficients for all variables, but in particular for elevation and the easting-northing gradient. Wild boar selected intermediate elevations and avoided agricultural areas, whereas roe deer strongly avoided meadows and areas with high road densities (Table XI.3). Comparing across species, the sika deer model was the best (Figure XI.2), with the highest classification success (83.4%), ROC score (0.89), Nagelkerke's R^2 ($r_{nagelkerke's}$=0.38) and k-folds cross validation both within the intensive (r_s=0.91) and across the extensive (r_s=0.96) study areas (Table XI.3). The roe deer (Figure XI.3) and wild boar (Figure XI.4) models were adequate, with reasonable diagnostics, but did not perform as well as the sika model in predicting out-of-sample locations in the intensive study area.

Predicted habitat quality for roe deer, sika deer and wild boar were highly correlated (roe and sika, r = 0.95; boar & sika, r = 0.83; boar and roe deer, r = 0.76), although not apparently too confounded based on the magnitude of coefficient change of 20-50% when combined in the same models (Hosmer and Lemeshow 2000). The degree of confounding, as well as the univariate strength of selection by leopards (B = 11.2, compared to 4.9 and 2.6 for roe deer and boar, respectively; see also Figure XI.1) and model selection support for sika deer (ΔAIC between sika and roe deer model was = 103) all supported the greater importance of sika deer to leopards in a spatial sense in our intensive study area.

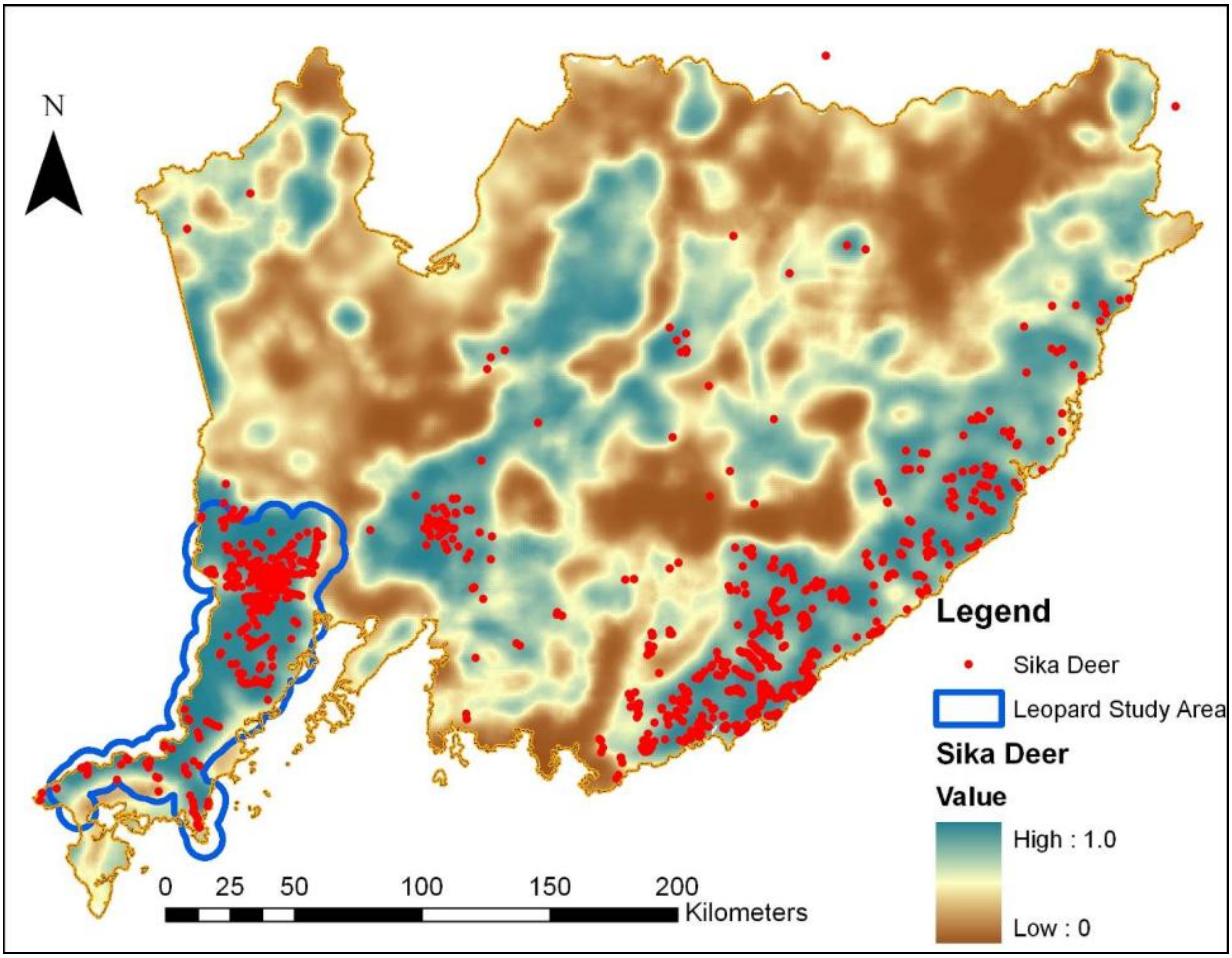


Figure XI.2. Probability of Occurrence for Sika Deer in the extensive Russian Far East Far Eastern Leopard reintroduction study area, winter 2005

Far Eastern Leopard RSF Model

From a model selection viewpoint, inclusion of any prey covariates dramatically improved model fit and explanatory power, with probability of leopards increasing with all measures of prey occurrence (Table XI.4). Univariate analysis of the other 2 prey species confirmed that indeed, leopards showed the strongest spatial selection for sika deer habitat (Figure XI.5). Moreover, sika deer were the most important prey species combined with these top environmental factors driving leopard resource selection (Table XI.4). However, the limited distribution of sika deer throughout the extensive study area (Figures XI.1 and XI.2) cautioned against using this sika-only model for extrapolation because leopards could rely on other prey species across the southern Sikhote-Alin in the absence of sika deer (see section 5.3). The sika deer model also predicted more poorly in the extensive area than the roe deer model (Table XI.3). Therefore, because diet analyses suggest that leopard can rely on both sika and roe deer as primary prey, and do use wild boar as well in small amounts, we also evaluated models with both sika and roe deer combined, and with all three species combined. From a model selection perspective, the model with all three species showed reasonable model fit compared to the sika deer model, and had similar explanatory power. Therefore, we chose this model as the top predictive model for the potential reintroduction study area.

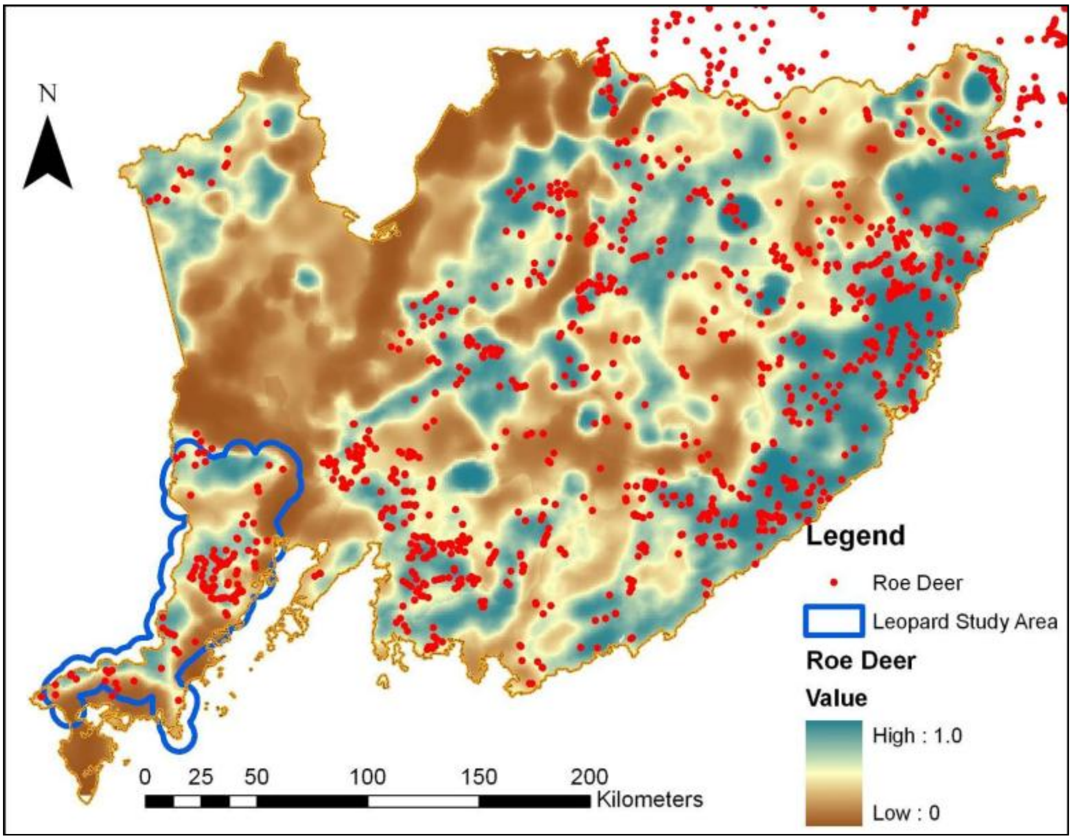


Figure XI.3. Probability of occurrence for roe deer in the extensive Russian Far East Far Eastern Leopard reintroduction study area, winter 2005

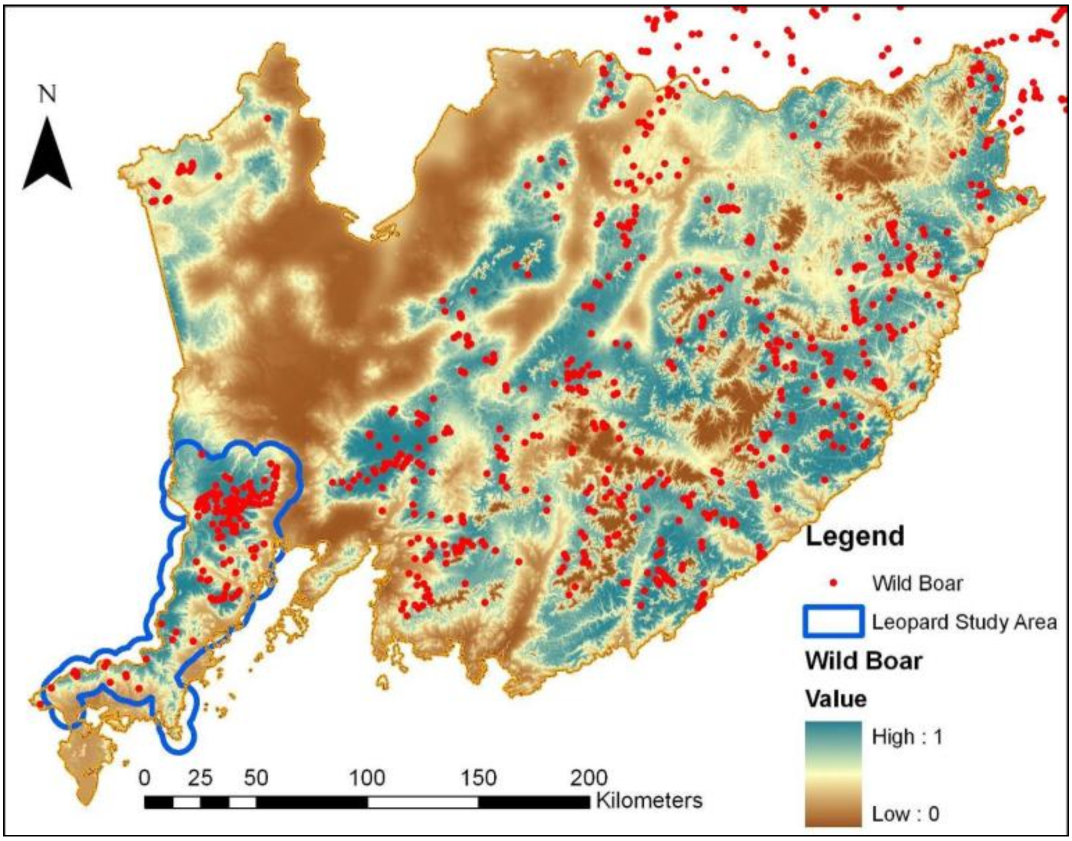


Figure XI.4. Probability of occurrence for wild boar in the extensive Russian Far East Far Eastern Leopard reintroduction study area, winter 2005.

Table XI.3 Resource Selection Probability Functions (RSPF) for sika deer, roe deer and wild boar in the Russian Far East in support of Far Eastern Leopard habitat modeling during winter 2005. Number of used and unused sample units that were used to develop logistic regressions, logistic regression measures of goodness of fit, and k-folds cross validation Spearman rank correlations between expected and observed frequency of used locations within the extensive and intensive study areas (see methods). Beta Coefficients (β) and standard errors for the top model for each species are reported.

	Sika Deer		**Roe Deer**		**Wild Boar**	
N_{used} / N_{unused} units	147 / 482, 0.30 prevalence		282/421, 0.67 prevalence		211/421, 0.5 prevalence	
Hosmer Lemeshow LR X^2 (df = 8)	8.38, P = 0.40		4.66, P = 0.79		13.91, P = 0.08	
Nagelkerke's R^2	0.38		0.16		0.18	
ROC	0.89		0.73		0.70	
% Classification success	83.4%		71.9%		69.8%	
Extensive k-folds r_s	0.91		0.93		0.84	
Intensive k-folds r_s	0.96		0.87		0.85	
Covariate	**B / SE**	**SE**	**B / SE**	**SE**	**B / SE**	**SE**
Agriculture	**--**	**--**	**--**	**--**	**-1.82**	**1.02**
Oak	**3.68**	**0.783**	**1.33**	**0.60**	**0.96**	**0.423**
Birch	**2.77**	**1.13**	0.74	0.59		
Regen	**6.27**	**3.21**	**4.65**	**2.94**		
Korean pine	**2.11**	**0.810**	**--**	**--**	**1.27**	**0.468**
Shrubs	---		1.17	1.02		
Meadows	---		**-3.16**	**1.49**		
Distance to Zapovednik	**-0.044**	**0.010**	**--**	**--**	**-0.0177**	**0.006**
Road density/10km^2	**-4.89**	**1.483**	**-1.50**	**0.887**	**-0.59**	**0.24**
Snow cover (%)	0.16	0.090	-0.023	0.013	-0.007	0.004
Snow quadratic	**-0.0023**	**0.0012**	**--**	**--**		
Elevation (m)	---		-0.0012	0.0008	**0.010**	**0.002**
Elevation quadratic	--		--	--	**-0.000012**	**2.97e-6**
Easting * Northing[a]	**-6.75e-13**	**1.16e-13**	**2.58e-13**	**7.63e-14**	--	--
Coastal zone	**0.11**	**0.030**	**-0.15**		--	--
Intercept[b]	**6.29**	**1.20**	0.933	0.480	-0.91	0.773

a- Easting * Northing is a spatial variable created by the multiplication of easting and northing to create a southwest-northeast spatial gradient in Sika deer distribution.

b- Intercept includes as the reference category all excluded habitat covariates, for example, for Sika Deer, the intercept includes agriculture, spruce-fir forests, larch forests deciduous, shrubs, meadows, alpine, wetlands.

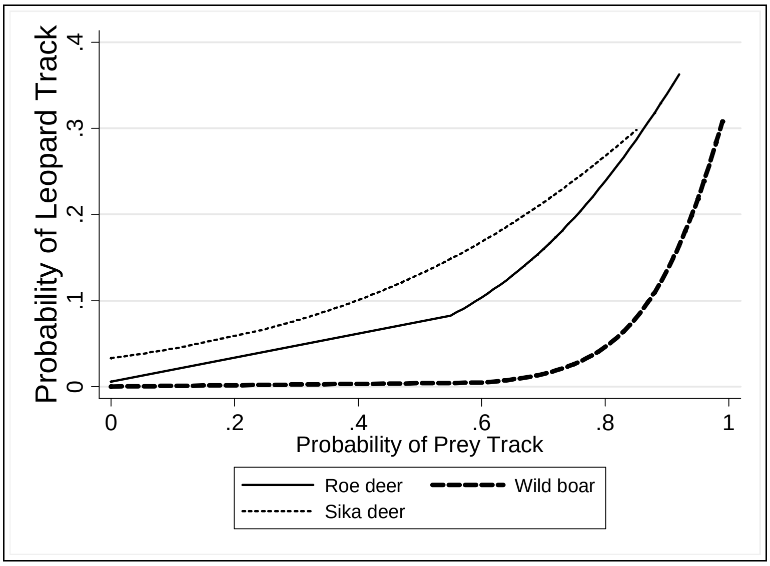


Figure XI.5. Relative probability of observing a leopard track as a univariate function of the ungulate habitat models for the three top ungulate species in leopard diet, Roe deer, Sika deer and Wild boar, SW Primorye Krai, Russian Far East, 1997-2007.

This combined prey RSF model showed that leopard resource selection was lower than expected for riverine forests, meadows, shrub and agricultural landcover types, with selection for Korean pine forests (Table XI.5). The relative probability of Far Eastern leopard selection increased in areas farther from main roads, with lower winter snow cover, closer to and inside Zapovedniks, at lower elevations, and lower hillshade values (southerly aspects) (Table XI.5). Overall model diagnostics revealed good model fit, with a Hosmer and Lemeshow goodness of fit test X^2=15.11, P = 0.07, a ROC score of 0.789 (diagnostic of adequate model performance), and a 74.3% overall classification success at the optimal cutpoint probability of 0.23. More importantly for use-availability designs, the k-folds cross validation score for the leopard data used to build the RSF model (internal cross validation) was $\boldsymbol{r_s}$= 0.95 (SE = 0.023). When applied to the independent survey data (external cross validation) from 2005, the predictive capacity of the model was also high, with an $\boldsymbol{r_s}$= 0.901 (SE = 0.049). The map of predicted leopard habitat matched observed leopard tracks relatively closely within Southwest Primorye (Figure XI.6).

Table XI.4 Far Eastern leopard resource selection function (RSF) model selection results for Southwest Primorye, and k-folds predictive cross-validation. The top environmental model is compared to different combinations of environmental variables and leopard ungulate prey species; sika deer, roe deer, wild boar, all prey species, and averaged roe deer and sika deer, Russian Far East, 1997-2008. The smaller the AIC, the better the model, and the higher the k-folds cross-validation value, the better the model predicts leopard presence.

Model	Log-likelihood	d.f.	AIC	ΔAIC	k-folds
Environment	-1609.1	11	3240.1	144.9	0.79
Roe deer	-1558.8	12	3141.6	46.4	0.91
Sika deer	-1535.6	12	3095.2	0	0.96
Wild Boar	-1530.2	12	3214.4	119.2	0.89
All 3 species (Boar + Sika + Roe)	-1538.06	12	3098.1	2.9	0.95
2 species (Sika + Roe)	-1548.1	12	3120.1	24.9	0.92

Table XI.5 Top Far Eastern Leopard RSF for the relative probability of selection at the study area scale in the Russian Far East, SW Primorsky Krai, 1997-2007. Bold values are significant at p=0.01.

Coefficient	B	SE
Deciduous Riverine	**-0.95**	0.460
Meadows	**-0.67**	0.272
Shrubs	**-0.74**	0.222
Korean Pine	**0.31**	0.121
Agriculture	**-1.28**	0.478
Ungulate Prey	**5.27**	0.802
Distance to main roads (km)	**0.145**	0.015
Snow cover (MODIS)	-0.34	0.204
Hillshade	**-0.0027**	0.0007
Dist (km) to Zapovednik	**-0.053**	0.007
Elevation (m)	**-0.0036**	0.0004
Constant (β_0)[1]	**-4.94**	0.710

1-The constant (β_0) includes as reference categories birch, oak, Korean pine, meadow, and agriculture, which were not significantly different from each other.

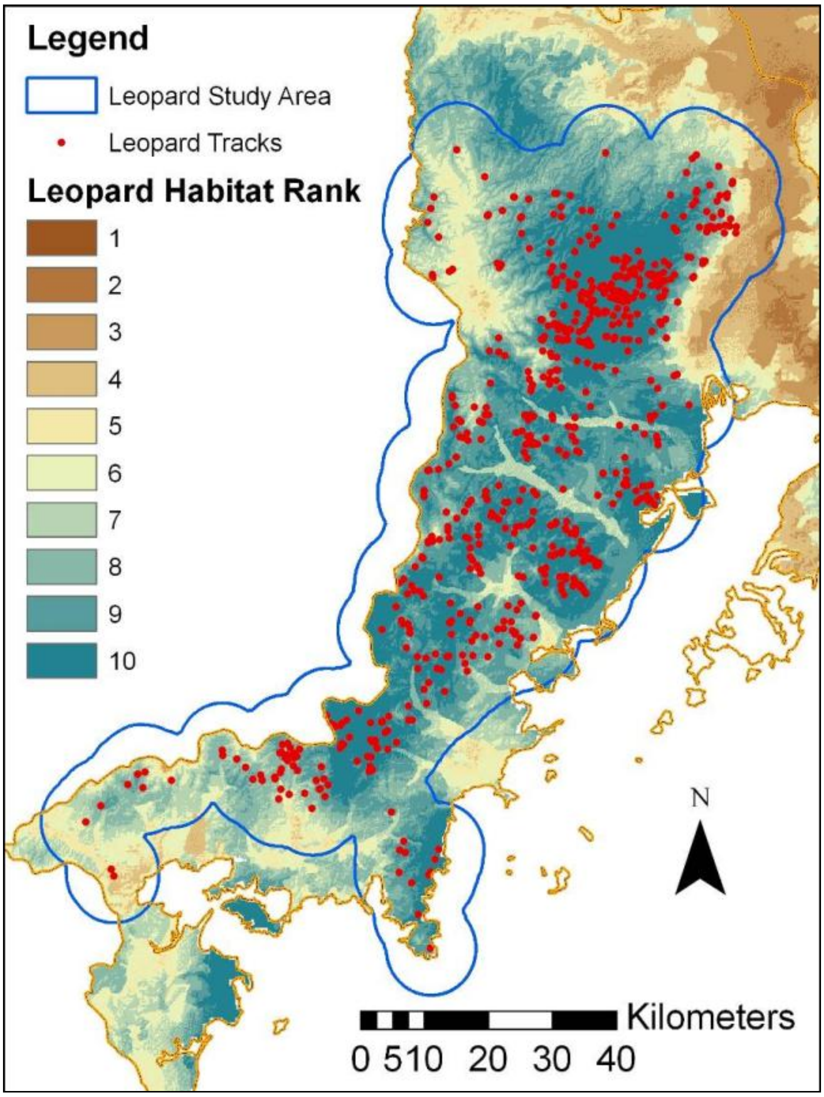


Figure XI.6. Predicted Far Eastern leopard habitat quality in Southwest Primorye using all three prey species, and distribution of leopard tracks from surveys conducted from 1997-2007.

Delineating Potential Reintroduction Patches

Extrapolating the best leopard RSF model to the proposed reintroduction area revealed several distinct areas of potential Far Eastern leopard habitat adjacent to their current distribution. The largest patches of suitable habitat appeared in the coastal regions (Figure XI.7). Using a cutpoint probability of P = 0.11 assured 89.2% correct classification of leopard tracks. Applying this cutpoint to the predictions in the proposed reintroduction area, and selecting habitat patches that were at least 500 km2 in size, we identified 7 large habitat patches of potential habitat in southern Sikhote-Alin (Figure XI.8). There were additionally 14 patches of suitable habitat that were at least 100 km2 in size. (Figure XI.8). Pogranichny Raion held only small patches of habitat.

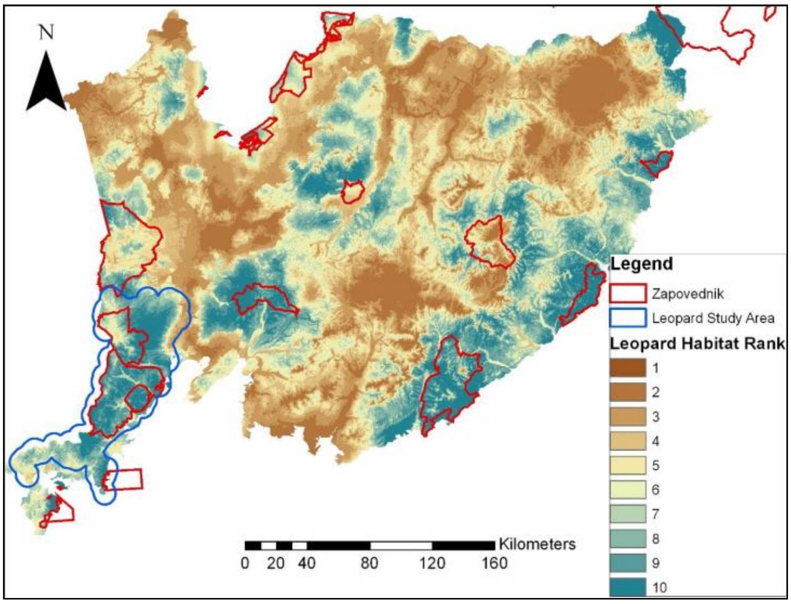
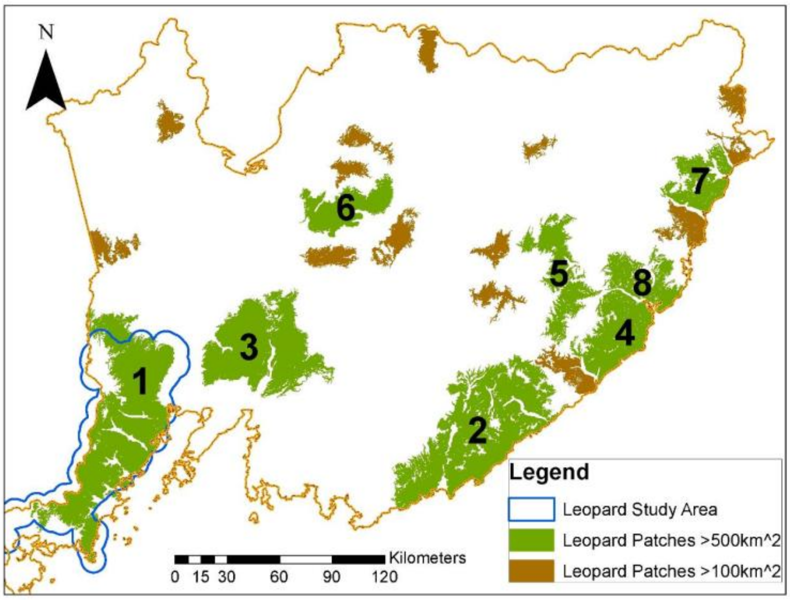


Figure XI.7. Predicted Far Eastern leopard habitat based on the best model developed in for Southwest Primorye. Predicted Far Eastern leopard habitat quality is shown in equal-area ranked categories from 1 (low quality) to 10 (high quality).



.Figure XI.8. Predicted patches of Far Eastern leopard habitat obtained by applying the top leopard RSF model and the optimal cutpoint probability to correctly classify 90% of leopard tracks within the intensive leopard study area. Patches >100km^2 and >500km^2 are shown to identify potential connectivity and population patches, respectively.

Evaluating Patch Connectivity

Least cost path analysis between potential leopard patches >100km^2 revealed several discontinuous larger areas of potential leopard habitat (Figure XI.9). The most connected patches were along the coastal areas. Patches 5, 4, and 8 were the three most interconnected patches, followed by patch 2 and then 7 north along the coast via two smaller 100 km^2 patches. The currently occupied Southwest Primorye population was most closely associated with the suitable habitat around Ussuriisky Zapovednik, but connectivity is unlikely there based on least-cost path analysis. Similarly, the patch of habitat surrounding Ussuriisky Zapovednik does not appear well connected to the Siniy Khrebet patch (Figure XI.9), which is the most isolated patch > 500 km^2.

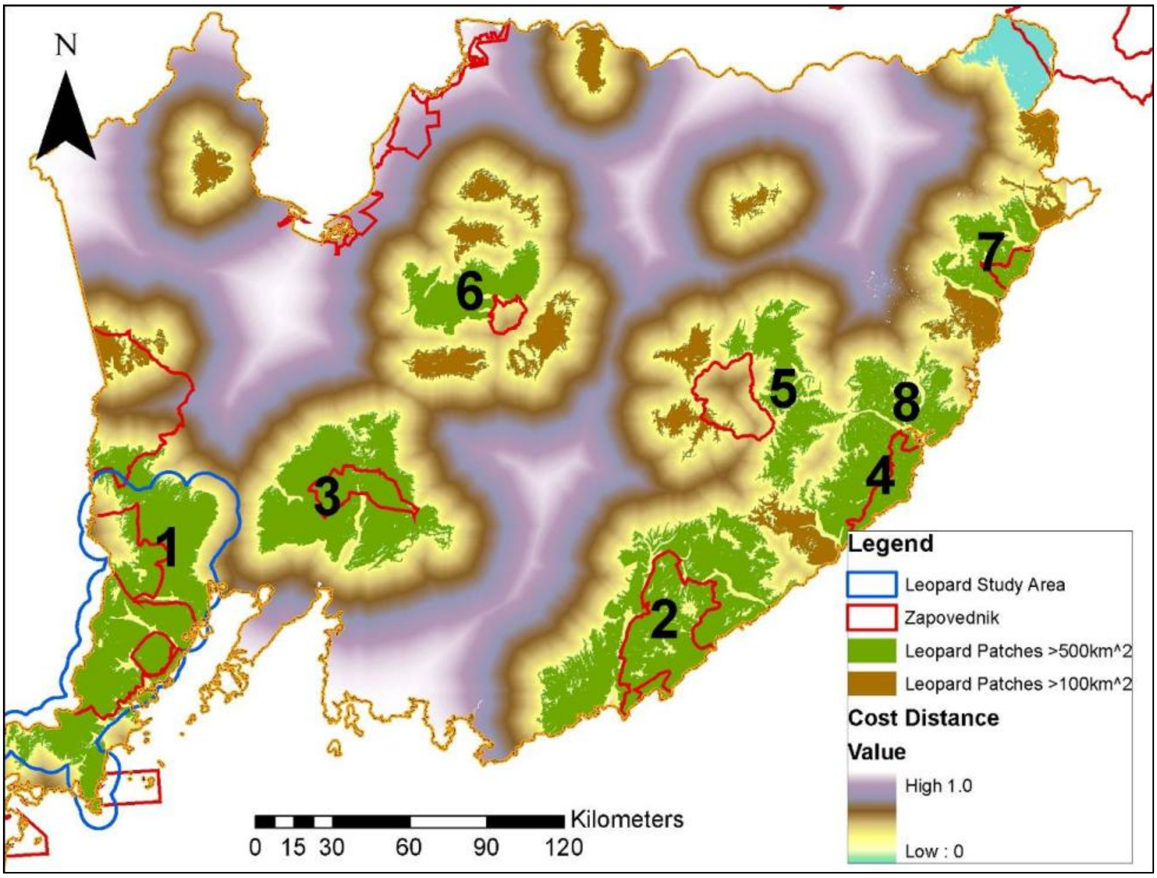


Figure XI.9. Connectivity of potentially suitable leopard habitat in southern Sikhote-Alin based on least-cost analyses.

Estimating Potential Leopard Population Size

Using a mean adult leopard population size of 30.8 (SD 6.45) individuals for Southwest Primorye, we predicted a potential combined total of 146 (84.8-201.1) adult Far Eastern Leopards could potentially occupy all 8 patches in the southern Russian Far East (i.e., including Southwest Primorye (Table XI.6). Excluding the currently occupied portion of the SW Primorye Krai patch, an additional 116 (estimated range from 66 to 158) adult Far Eastern leopards could possibly occupy the remaining patches. Combining the 5 most connected patches of Far Eastern leopard habitat from Figure XI.9 (e.g., patches 2, 4, 5, 7, and 8) suggest that if individuals move between these 5 habitat patches, a total of 65 (38-89) Far Eastern leopards might be expected to occupy habitat along the coast as part of a single, connected metapopulation.

Table XI.6 Habitat-based population estimates for the eight largest patches of potential leopard habitat in the southern Russian Far East based on Far Eastern leopard resource selection function models developed in SW Primorye Krai, 1997-2007.

Patch #	Patch Name	Area	Population Size	Low	High
1a Occupied SW Primorye	SW Primorye – occupied [1]	3,501.5	30.8	17.7	42.3
1b	SW Primorye – northern unoccupied area	200.5	2.0	1.1	2.7
2. Lazo		3,378.7	31.6	18.2	43.4
3. Ussurisk		2,450.6	20.9	12.0	28.8
4. Southern Valley		1,209.7	14.9	8.5	20.4
5. Zov Tigre		1,018.6	7.4	4.3	10.2
6. N. Olga		888.3	7.7	4.4	10.6
7. Kavelerova		756.0	6.3	3.6	8.6
8. Siniy Khrebet		746.2	4.9	2.8	6.7
	Total – Potential habitat – Southern Sikhote-Alin	13,782	116	66.3	158.7
	Total – All 8 patches	17,284	146	84.8	201.1

1- SW Primorye Krai is itself split into 2 areas, inside and outside of the current extent of occurrence to account for potential connected habitat in this patch that is currently not used by leopards.