



Monitoring Amur Leopards and Tigers in the Russian Far East

Final Report

to

The Amur Leopard and Tiger Alliance (ALTA)

from the

WILDLIFE CONSERVATION SOCIETY (WCS)

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SUMMARY

From March to June 2011 we recorded 156 leopard photographs, bringing our grand total of leopard camera trap photographs (2002-present) to 756. In 2011 we recorded 17 different leopards on our study area, the most ever in nine years of monitoring. While most of these likely represent transients, it is still a positive sign that the population is reproducing and at least maintaining itself. Additionally, camera trap monitoring in an adjacent unit just south of our study area reported 12 leopards, bringing the total minimum number of leopards to 29. Collectively, these results suggest that the total number of leopards in the Russian Far East is presently larger than the 30 individuals usually reported. We also recorded 7 tigers on the study area, including 3 cubs. The number of adult tigers on the study area has remained fairly steady over all nine years of the monitoring program.

INTRODUCTION

The Amur leopard (*Panthera pardus orientalis*) is the northern-most of the nine extant subspecies (Miththapala et al., 1996; Uphyrkina et al., 2001), with a very small global distribution in the southernmost corner of the Russian Far East (two counties in Primorye Province), and in neighboring Jilin Province, China. Recent surveys in Heilongjiang Province (China) and in North Korea (Sun et al. 1999; Kim Jin Rak et al. 1998) did not detect any leopard signs (although newer camera trapping efforts in China are indicating that there are some leopards along the Russian border). The Amur leopard is listed as Critically Endangered on the IUCN Red List (IUCN Red List; Nowell & Jackson, 1995), with a suite of complicating factors contributing to this status: the population is geographically and genetically isolated, logging and fires are annually and systematically reducing suitable habitat, prey numbers are low due to ineffective ungulate management and poaching, and leopards themselves are targets for poachers.

Tigers also overlap with leopards in Southwest Primorski Krai, and represent a sub-population wholly or partly isolated from the main population in the Sikhote-Alin Mountains. It is this sub-population that represents the source for dispersal into the Changbaishan Mountains of China, and therefore its status is of significance not only to Russia, but to China as well.

Until recently, exact numbers of tigers and leopards in Russia have been difficult to estimate, with past estimates of leopards ranging from 22-50 (Pikunov et al., 1997; 2000, Aramilev and Fomenko, 2000). These numbers were gleaned primarily from winter track counts (Matyushkin et al., 1996). However such techniques may result in significant population estimation error (Miquelle and Smirnov, unpublished data) and do not have solid statistical support (Karanth and Nichols, 1998). This is due to the inherent subjectivity associated with such methods, with different analysts deriving different results from the same raw data (Miquelle, 2000). Population size of a critically endangered animal is an important metric by which conservation action can be measured, and therefore a statistically rigorous and repeatable methodology is desirable. Both tiger and leopard pelages contain markings unique to each individual, which makes it possible to

identify individuals from photographs. This feature has been used in India with success to develop camera trap techniques using established mark-recapture methods (Karanth, 1995). Here, we present recent results from Amur leopard camera trap efforts from southwest Primorye.

METHODS

We conducted camera trapping in the Nezhinskoe Hunting Lease and in the south-western corner of the Borisovskoe Plateau Wildlife Refuge in southwest Primorye (Fig. 1). For most of the 10 years that we have conducted camera trapping at this site, we have used CamTraker systems with film cameras (Forestry Suppliers, Jackson, MS, USA), but last year we supplemented these camera traps with digital units from Panthera. At most sites, we placed one CamTraker and one Panthera camera at each point to capture both sides of the passing animal, as leopard pelage is asymmetrical (Fig. 2; Karanth, 1995; Karanth and Nichols, 1998). Cameras were attached to trees so that the infrared sensors were located at a height of 45-50 cm above the trail, and at a distance of 3.5-4 m from the expected trajectory of the animal, as recommended by Nichols and Karanth (2002), and placed on game trails along the edges of ridges, spurs, or natural bottlenecks where animals could not avoid passing by camera traps.

Figure 1. Study area in southwest Primorye.

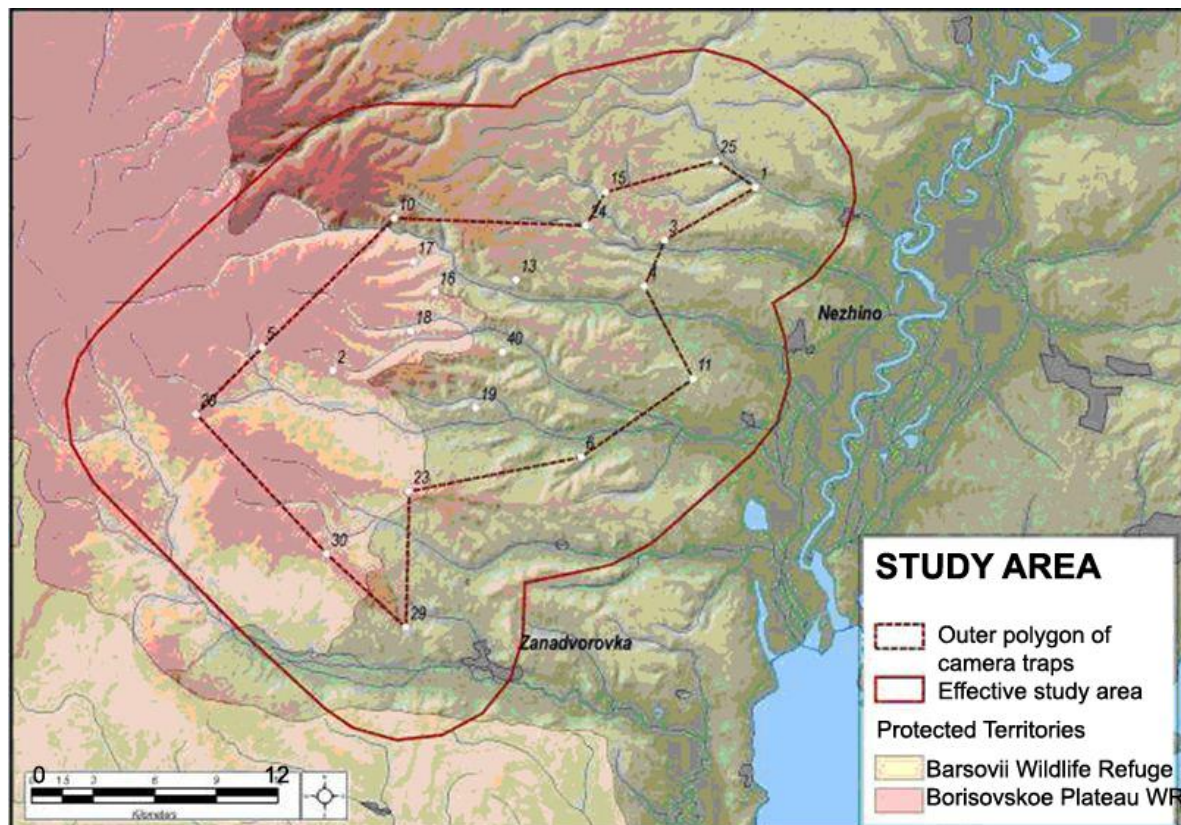


Figure 2. Asymmetry of Amur leopard pelage.

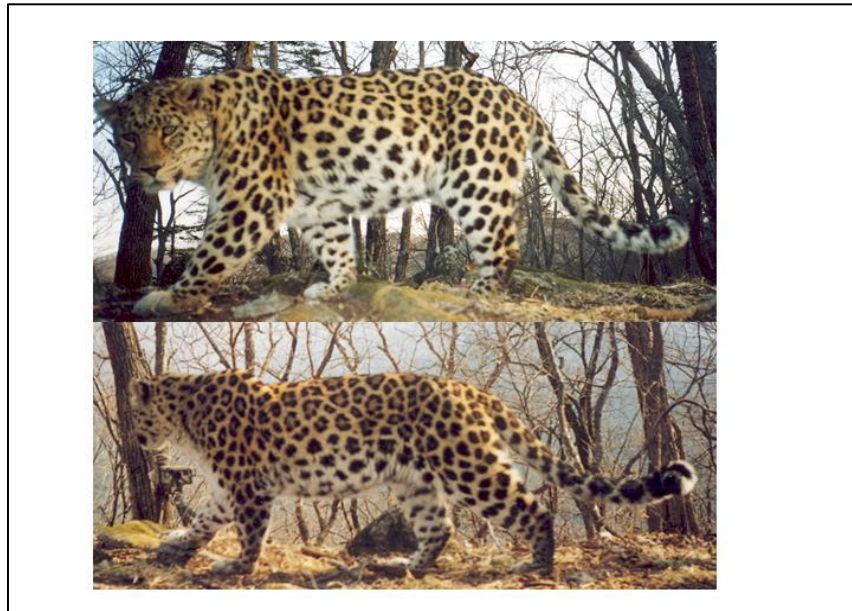
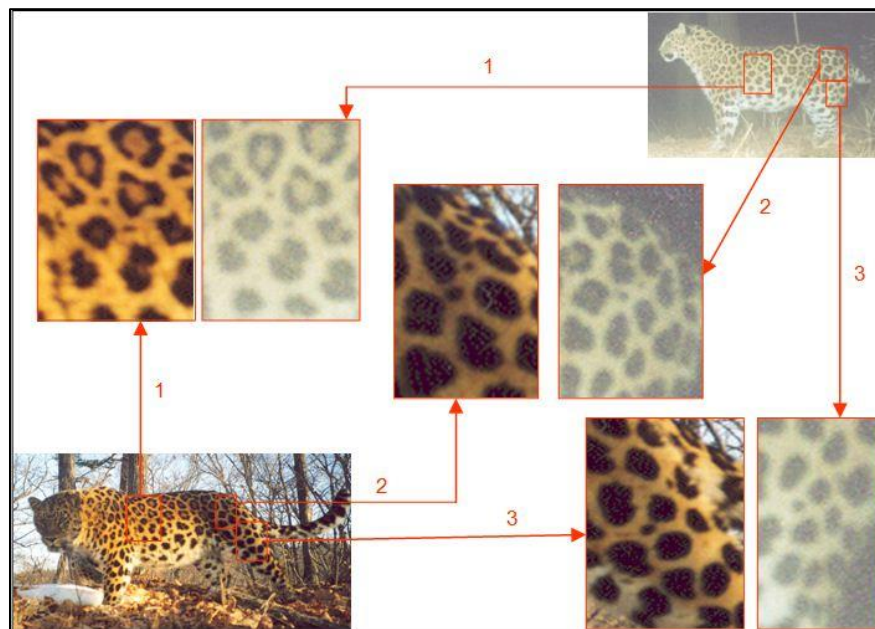


Figure 3. Schematic showing how form and location of rosettes leads to identification of individual Amur leopards.



We placed cameras at 21 locations (a total of 42 cameras) that have been fixed for the duration of monitoring within a 270 km² area. The average distance between camera traps was 3.7 km (min = 1; max = 6.5 km; Fig. 1 shows camera trap dispersion). Given that female Amur leopard home ranges are 45-65 km² (Augustine et al., 1996), we estimate that this sampling scheme results in

2-3 camera traps in each female's home range. Camera traps were checked at intervals of 5-6 days. Leopards were identified by comparing the shape and size of pelage rosettes and their specific locations on both sides of the animal (Fig. 3).

Assessment of Amur leopard daily activity patterns is not possible by direct observation due to their secretive lifestyle, and such data have not previously been collected. Therefore, we also analyzed our camera trap data to gain an understanding of daily activity based on the variation of the number of captures at different times of the day. To do this we divided the day into 6 periods of 4 hours each, and tallied the number of captures per period.

RESULTS

Leopards

In 2011, data were collected from mid-March to early June, and resulted in 156 photographs of 17 individual leopards over 2,381 camera days (Table 1). In total (2002-2011) we have camera trapped and identified 41 individual Amur leopards (Table 2; see also Appendix 1 for examples). Of these 41 individuals, there is a relatively even sex ratio of 14 males, 17 females, and 10 unknown sex. Thirty-seven of these leopards were adults or subadults, and four were cubs (Table 2). However, because in most years we used film-based camera traps that have a long delay before firing a second time, our surveys will clearly miss cubs following mothers, resulting in an underestimate of reproduction. Of the 37 adults, 46% ($n = 19$) were only camera trapped once, suggesting that those animals were transients, whereas the same individuals captured multiple years suggests site fidelity (i.e., residents; Table 2). Using data from Table 2, we can construct a crude estimate of "survivorship" by looking at the total number of years leopards were present or could be confirmed alive by photographs in subsequent years. These data (Figure 4) suggest that the vast majority of leopards are transients or have low survival rates, as they are photographed in only one or two years. There are very few animals that persist for even 4-6 years of our study, but there appear to be resident adults who have high survival rates and have been on the study area for the majority of the years in which our surveys have been conducted. These data suggest the survival rates of resident adults appear quite high, but there is high turnover of transients.

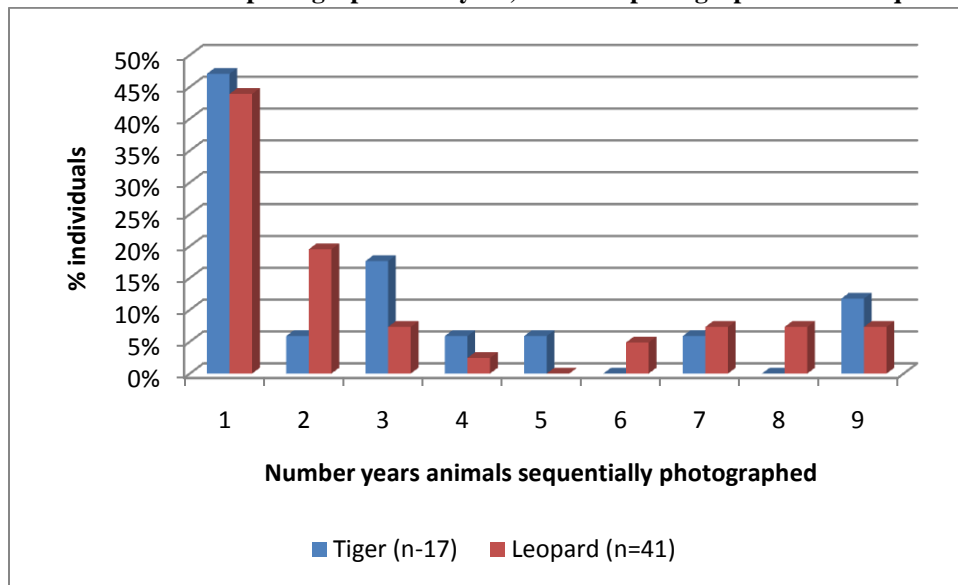
For 2011 data, the number of leopards estimated in the study area using capture-recapture models ranged from 17 to 20, depending on the model used (Table 3). Despite the wide 95% confidence interval for model M_h , we believe that the actual number of individuals to be close to N , which is the highest estimate derived for any year of our monitoring.

The maximum distance between repeat leopard "captures" ranged from 2.48 to 24.47 km, and the mean distance across all years was 11.63 km. From this overall mean distance we calculated the width of buffer zone W for leopards to be 5.81 km (half the mean distance between locations) (Table 4). As a result, the size of effective area $A(W)$ in our study was 831 km², and the average density of leopards in the study area was 2.4 individuals per 100 km² (when using the model M_h ; Table 4).

Table 1. Number of leopard photographs, captures, and the minimum number of leopards in the study area from 2003-2011.

YEAR	# Leopard Photographs	# Captures	Minimum # of Leopards
2002-2003	65	30	9
2004	69	34	13
2005	113	67	14
2006	63	28	9
2007	65	33	14
2008	56	29	8
2009	106	34	9
2010	63	41	12
2011	156	44	17

Figure 4. Number of years individual tigers and leopards identified on the study area were alive (including years where individuals were not photographed one year, but were photographed in subsequent years).



leo38	?	Adult									2
leo39	?	Adult									1
leo40	?	Adult									1
leo41	?	Adult									1

Table 3. Amur leopard numbers in the study area.

YEAR	MODEL							
	M_0				M_h			
	\bar{N}	S	95% CI	p	\bar{N}	S	95% CI	p
2003	10	0.7	10-10	0.223	11	2.8	11-27	0.203
2004	14	1.2	14-20	0.158	16	3.6	14-31	0.133
2005	14	0.4	14-14	0.252	15	2.8	15-32	0.236
2006	9	0.8	9-14	0.2209	10	3	10-28	0.2
2007	16	1.8	15-23	0.187	19	4.2	16-35	0.153
2008	8	0.4	8-8	0.2589	11	2.5	9-20	0.242
2009	9	0.3	9-9	0.2593	11	2	10-19	0.212
2010	14	1.9	13-22	0.1358	18	5.1	14-37	0.1026
2011	17	2.8	15-28	0.146	20	3.7	15-32	0.1389

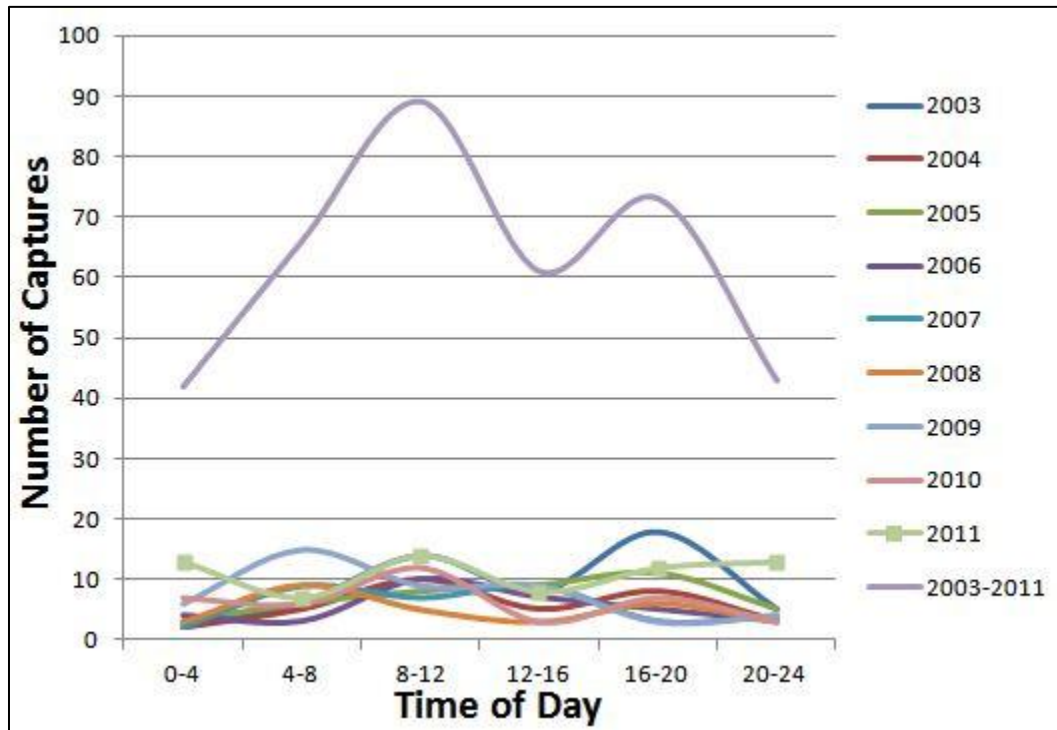
Table 4. Amur leopard density in the study area.

YEAR	AREA COVERED BY CAMERA TRAPS (km ²)	MAXIMUM AVERAGE DISTANCE BETWEEN CAPTURES (km)	BUFFER WIDTH W (km)	EFFECTIVE AREA (km ²)	MEAN POPULATION DENSITY (individuals/100 km ²)	
					$\bar{D} \pm S$	
		$\bar{d} \pm S$	$W \pm S$	$A(W) \pm S$	MODEL $M_{(0)}$	MODEL $M_{(h)}$
2003	274	13.2±1.6	6.6±0.8	926±88	1.1±0.1	1.2±0.3
2004	274	13.2±1.3	6.6±0.7	926±71	1.4±0.2	1.5±0.3
2005	274	11.1±1.3	5.5±0.7	796±65	1.8±0.16	1.9±0.39
2006	274	11.8±1.6	5.9±0.8	845±83	1.1±0.16	1.2±0.36
2007	270	11.8±1.1	5.9±0.6	837±63	1.9±0.25	2.3±0.45
2008	270	11.9±1.3	6.0±0.3	845±38	0.9±0.13	1.3±0.34
2009	270	12.2±2.7	6.1±0.7	860±81	1±0.13	1.3±0.34
2010	270	12.3±1.1	6.16±0.5	867±57	1.6±0.24	2.1±0.61
2011	270	11.6±1.3	5.8±0.6	831±66	2±0.21	2.2±0.21

Leopard daily movements

Here we assumed that a relationship exists between the frequency of leopard captures during a certain time of the day and their overall activity patterns. Based on seven seasons of winter field data, we show that the circadian rhythm of Amur leopards for this season is a bimodal curve, with the first peak in the morning hours from 8:00 am to 12:00 pm, and the second peak in evening hours from 16:00 to 20:00 (Fig. 5).

Figure 5. Amur leopard activity patterns.



Tigers

Throughout all years of study (2003-2011) we have camera-trapped 17 individual tigers (Table 5). Of these, 76% were adults ($n = 13$) and 24% ($n = 4$) were cubs. Six of the adults were males, six were females, and the sex of five adult individuals could not be determined (the sex of all four cubs was also unknown). Forty-seven percent of these tigers ($n = 8$) were only camera-trapped one year (suggesting they were transients), two (12%) survived through all nine years of the study (but were not photographed in every year) and only three (18%) survived or stayed in the study area at least four years. Although sample sizes are smaller, the same pattern shown by leopards appears to exist for tigers: the majority of tigers appear to be transients, with just a few resident individuals with high survival rates, and very few individuals that do not fit one of these two categories (Fig. 4). Sample sizes are insufficient to estimate tiger numbers using capture-recapture models.

Table 5. Number of tiger captures 2003-2011.

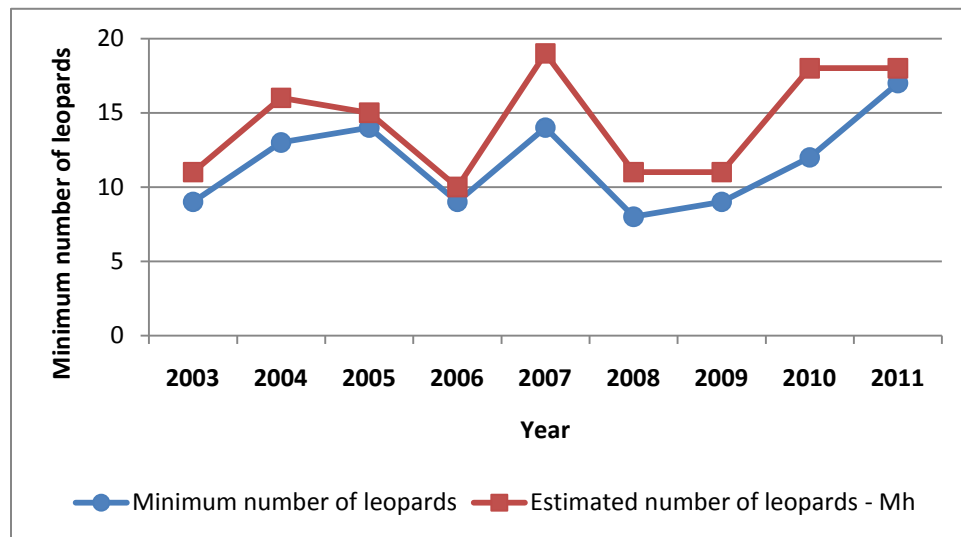
Individual and sex	Sex	Age	Number of Captures Per Year								
			2003	2004	2005	2006	2007	2008	2009	2010	2011
Pt1	F	Adult	2	1	2					3	3
Pt2	F	Adult	3	1	1		2	1	4	2	2
Pt3	M	Adult			1	1	1				
Pt4	M	Adult	1	1	6	1					
Pt5	F	Adult				2				2	
Pt6	M	Cub	1								
Pt7	?	Adult					1				
Pt8	M	Adult		1				1		1	
Pt9	M	Adult						2	1	1	
Pt10	?	Adult						1			
Pt11	M	Adult							1	1	1
Pt12	F	Adult							1		
Pt13	F	Adult								2	2
Pt14	F	Adult								1	
Pt15	?	Cub									2
Pt16	?	Cub									2
Pt17	?	Cub									2

CONCLUSION

Yearly estimates of leopard numbers have varied from as low as nine individuals in 2003 to this year's high of 17. The good news is that the overall trend from 2003 to 2011 (9-17) is positive. However, it is clear in looking at yearly fluctuations (blue line, Fig. 6) that there has not been a steady upward trend in leopard numbers in the study area. Low numbers of 8 and 9 were also reported in 2008 and 2009. Looking at estimates derived from capture-recapture models should provide a more robust estimate of trends, but in fact the same pattern of fluctuations appears to exist in both the minimum estimate and the modeling estimate (red line, Fig. 6).

The increased number of leopards in 2011 is partially a result of using new cameras: Panthera digital cameras have a fast "recovery" period, and have the capacity to take pictures in rapid succession, which allowed us to photograph two leopard cubs in camera traps for the first time ever. Therefore, total numbers of adults was only 15, which is probably a more realistic value to compare to previous years.

Figure 6. Yearly estimates of leopard numbers, based on minimum number of leopards photographed, and the estimate derived from the capture-recapture “Mh” model which assumes heterogeneity in probability of capture.

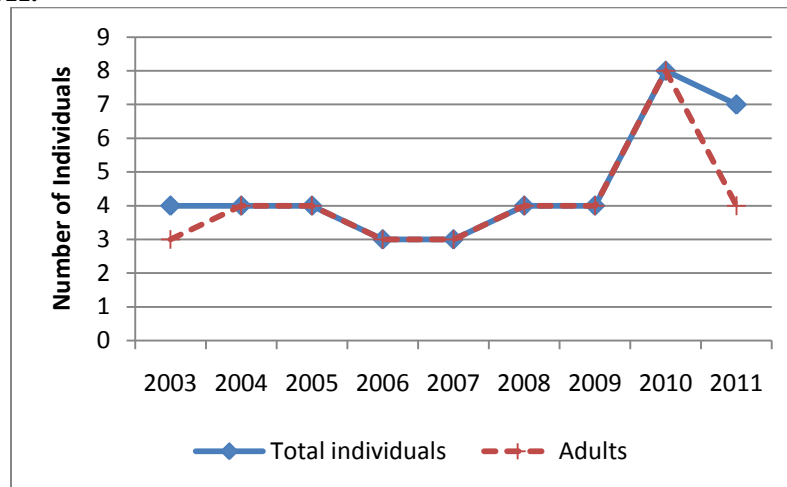


We also suspect that a large number of the leopards photographed in 2011 represent transients that are unlikely to be present next year. Generally, we have found that a relatively small portion of the animals photographed are permanent residents who appear in our monitoring repeatedly for many years (Fig. 4).

Despite these tempering facts, the data from our monitoring site must be considered “good” news. Even if many of these leopards are transients, and a few of the photographed leopards were cubs, both these facts are indicators that there is robust reproduction, and that animals are dispersing in search of suitable habitat. This fact gives all the more importance to habitat management on the Chinese side of the border, which probably represents the only likely direction in which leopards can disperse and find uninhabited (by leopards) habitat. Survey work in China has begun to photograph leopards along the Russian border, giving credence to this perspective that dispersal in that direction is likely. Given that reproduction and dispersal is occurring, habitat improvement (to increase the prey base) must be a priority for both Russia and China to provide an opportunity for an increase in numbers of true residents on both sides of the international border.

The number of tigers on the study site appears to be more stable than that of leopards (Fig. 7). There have been 3-4 adult tigers on the study area in all years except 2010, when two new females arrived on the study area. The spike in total numbers this year can be attributed to the existence of a litter of 3 cubs that were photographed twice by our camera traps. As with leopards, the presence of cubs and transients suggests that reproduction is good, and that the population appears to be sustaining itself.

Figure 7. Minimum number of adult and total number of tigers (including cubs) photographed on the study site from 2003 to 2011.



ACKNOWLEDGEMENTS

We sincerely appreciate the Amur Leopard and Tiger Alliance's role as a key partner in our ongoing efforts to conserve Amur leopard and Amur tiger populations in the Russian Far East. With ALTA's support, we are making important strides toward the basic ecology of these endangered species. We believe that this is essential information for conserving leopards and tigers in their remaining habitat of the southern Russian Far East.

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APPENDIX 1. Examples of camera trap photographs of Amur leopards and Amur tigers in southwest Primorye, Russia.



Fig. 1. What appears to be a female and male pair along a ridgeline.



Fig. 2. A male leopard walking a ridgeline.



Fig. 3. Noting time of day photos are taken allows us to estimate activity patterns of leopards.



Figure 4. An adult female leopard approaches her den site, where cubs await her return.



Fig. 5. An adult female at a kill site.



Fig. 6. First ever photo of an Amur leopard and her young kitten at a densite.



Fig. 7. An adult Amur tiger walks through a camera trap set.