A MONITORING PROGRAM FOR THE AMUR TIGER

TENTH-YEAR REPORT: 2006-2007

In accordance with the Russian National Strategy for Tiger Conservation

A cooperative project conducted by representatives of:

Wildlife Conservation Society
All Russia Research Institute of Wildlife Management, Hunting, and Farming
Institute of Geography, Far Eastern Branch of the Russian Academy of Sciences
Institute of Biology and Soils, Far Eastern Branch of the Russian Academy of Sciences
Sikhote-Alin State Biosphere Zapovednik
Lazovski State Zapovednik
Ussuriski Zapovednik
Botchinski Zapovednik
Bolshe-Khekhtsirski Zapovednik
Institute for Sustainable Use of Renewable Resources
World Wide Fund for Nature

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TENTH-YEAR REPORT: 2006-2007 WINTER

Executive Summary

For the first time in the 10 years of this monitoring program, the situation for tigers appears to be declining. Of the 117 indicators used to assess trends in tiger numbers, cub productivity, and prey abundance, 38% indicate negative trends, versus only 7% that indicate positive trends. While the majority of indicators (55%) suggest no positive or negative changes, the change in increasing numbers of negative indicators demonstrates that overall conditions are declining for tigers. In some places, this is noted by a decrease in key prey species, in a few places by declining cub productivity, and in some by indications that the number of tigers may be declining.

There is mounting evidence that red deer and roe deer numbers are declining generally across the Russian Far East, although it is more pronounced in some areas. For both species, it appeared that numbers were stable or slightly increasing across all sites through 2001 or 2002, and then started a decline through 2007. While there are not major trends for either wild boar or sika deer, there are few places where positive trends exist.

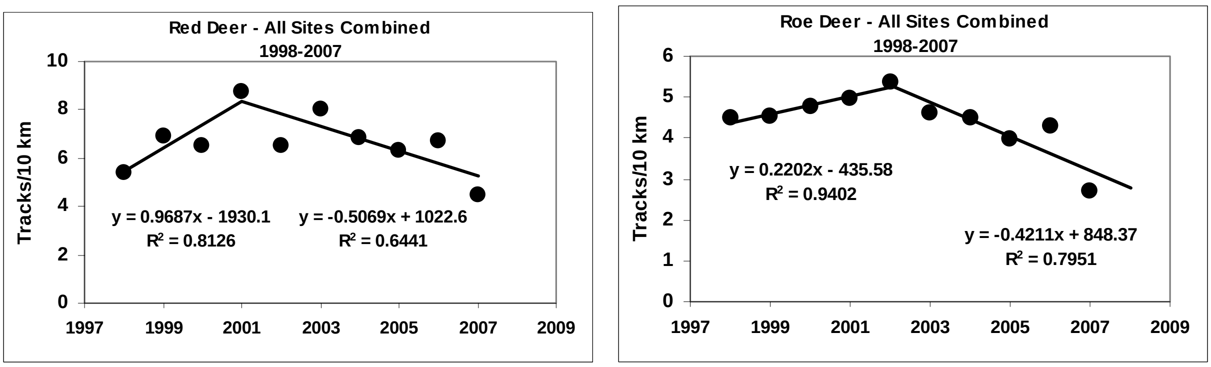


Figure i. Relative abundance of red deer and roe deer, based on track counts, averaged across all sites where they occur on the 16 monitoring units of the Amur Tiger Monitoring Program, 1997-1998 winter through 2006-2007 winter. For both species, it appears that numbers were slightly increasing or stable from 1998 through 2001 or 2002, when numbers started to decline. Values for 2007 are the lowest reported during 10 years of the monitoring program.

If conditions are deteriorating for tigers (in terms of decreasing prey), it is likely that reproduction will be affected prior to a decrease in tiger numbers. And indeed, the number of cubs reported on monitoring sites appears to be decreasing since 2001. Four sites reported cub density averaged over the past three years to be higher than the 10-year average by 20% or more, while 10 sites reported cub density 20% or more lower than the 10-year average for that site.

While there are strong signs of decline (2 of 3 indicators negative) in tiger numbers in only four of the sixteen units, half (8) of the monitoring units have at least one indicator suggesting negative trends, while only two suggest there may be an increase in tiger numbers. However, as already suggested, actual changes in tiger numbers are likely to be the last indicator to change.

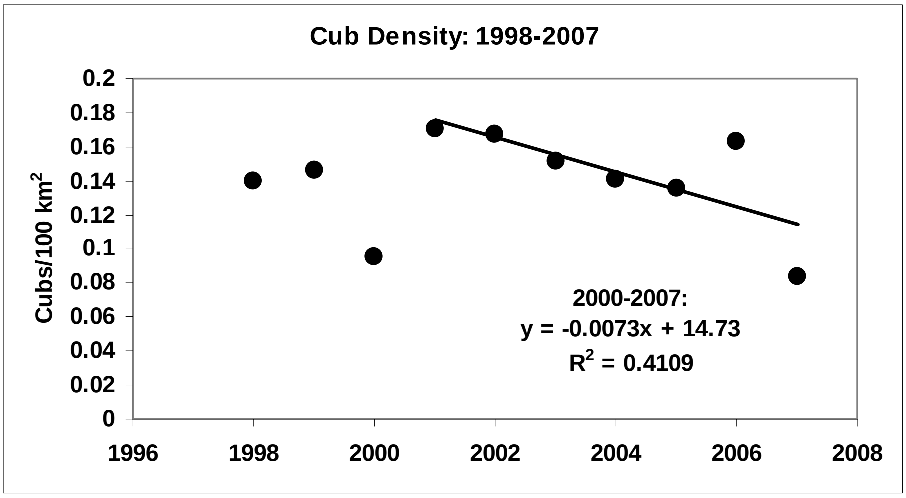


Figure ii. An estimate of reproduction rates, cub density is the number of cubs reported on each monitoring unit, divided by the size of that unit. Here, average values across all sites for each year indicate that numbers of cubs being produced on monitoring sites has started declining, as of 2001.

We suggest that to revert these trends, a number of changes are necessary; most importantly, law enforcement efforts must be improved. Changes in government structures and responsibilities have greatly reduced the effectiveness of law enforcement and control of poaching. We hope that as the new governmental structures responsible for managing hunting, and controlling poaching develop, this situation will change in a favorable direction. However, it is worth noting that changes in the Sikhote-Alin ecosystem clearly seem to be occurring, and that a decline in tiger numbers is possible until actions are taken quickly.

I. INTRODUCTION

At the international level, the Amur tiger (*Panthera tigris altaica*) is considered in danger of extinction. With only a few individuals remaining in China and an unknown number in North Korea, preservation of this animal has become primarily the responsibility of the Russian government and the Russian people. Accordingly, Russia has taken many steps to conserve this animal, starting with a ban of hunting in 1947. The Russian Federal government has since listed the animal as endangered (Russian Red Data Book), and has recently developed a National Strategy for Conservation of the Amur Tiger in Russia, as well as a Federal Program to implement the national strategy.

The recovery of the tiger after near extinction in the first half of this century (following the 1947 ban) has been fairly well documented through a series of surveys (Kaplanov 1947, Abramov 1962, Kudzin 1966, Yudakov and Nikolaev 1970, Kucherenko, 1977, Pikunov et al. 1983, Kazarinov 1979, and Pikunov 1990). Most recently, a range-wide survey provided a great deal of information on the distribution and status of tigers in the past decade (Matyushkin et al. 1996). Nonetheless, there remains a long standing need for a reliable and efficient means for monitoring changes in the tiger population.

The tiger is a rare, sparsely distributed, and secretive animal that is distributed across at least 180,000 km^2 of Primorski and Khabarovski Krais in southern Russian Far East. This combination of attributes make it a particularly difficult animal to count reliably, and the financial burden and logistical problems associated with range-wide surveys make it practically impossible to conduct full-range surveys with sufficient frequency to track changes in tiger abundance.

Nonetheless, there exists a need to monitor the tiger population on a regular (preferably yearly) basis. Such a monitoring program should serve a number of functions, including:

1. A monitoring program should act as an “early warning system” that can indicate dramatic changes in tiger abundance. Range-wide surveys, usually conducted between long intervals with no information, may come too late to allow a rapid response to a decline in numbers. Yearly surveys should serve to provide notice so that immediate conservation actions can be initiated.

2. Ultimately, tiger numbers, or at least trends in the tiger population, should be used as a basis to determine the effectiveness of conservation/management programs. In Russia, there have been tremendous efforts and significant support from regional, Krai-wide, federal, and international levels for implementation of tiger conservation efforts that range from anti-poaching programs to conservation education. All these efforts are aimed at protecting the existing Amur tiger population in Russia, yet without an accurate monitoring program that can determine trends in tiger numbers with statistical accuracy, the ultimate effectiveness of these conservation programs will remain unknown.

3. Among other indicators, a monitoring program should provide information on reproductive rate of the population, which may act most effectively as a predictor, or early indication of imminent changes even before there are dramatic changes in actual tiger numbers.

4. Changes in ungulate populations, as primary prey for tigers, may also provide important clues to potential impacts on tiger numbers.

In an attempt to address these needs, nearly all coordinators of the 1996 tiger survey have worked together to develop a reliable and effective monitoring program for Amur tigers. The task is a huge one, given the area involved and the logistics of working in a northern environment. The derived methodology has been tested over 5 years (1997-1998 winter through 2001-2002 winter season) and the results, as provided in the yearly reports, provides an indicator of the value of this program. .

II. GOALS AND OBJECTIVES

The ultimate goal of this program is the yearly implementation of a standardized system for collecting data that can be used to monitor changes in tiger abundance, and factors potentially affecting tiger abundance, across their present range in the Russian Far East. The intent is to provide a mechanism that will assess changes in the density of tigers, as well as other potential indicators of population status, within their current range over long periods of time. This methodology should provide a means of assessing the effectiveness of current management programs, provide a means of assessing new programs, and provide an "early warning system" in the event of rapid decreases in tiger numbers.

Objectives

Specifically, the objectives of this monitoring program are to:

1. Determine presence/absence of tigers on survey routes within count units as one indicator of trends in tiger numbers over time, and differences in tiger abundance among survey units in the Russian Far East.

2. Develop a standardized, statistically rigorous estimate of track density within count units as a second indicator of trends in tiger numbers over time, and differences in tiger abundance among survey units in the Russian Far East.

3. Develop an expert assessment of actual tiger numbers within count units as a third indicator of population trends over time.

4. Record presence of female tigers with young on count units across the range of tigers to monitor reproduction rates over time and identify areas of high/low productivity, and changes in reproduction over time.

5. Monitor trends over time in the prey base (large ungulates) of tigers within count units.

III. METHODOLOGY

The methodology has been provided in all past reports, and is therefore not repeated here. Details of methodology can be requested from the WCS Russia Program.

Additionally, it is worth noting that in 2007 we have finally published a monograph "Theoretical basis for surveys of tigers and their prey in the Russian Far East" which provides much of the background, history, and development of survey approaches in the Russian Far East. Unfortunately, this monograph is presently only available in Russia, but is obtainable by contacting the WCS Russia Office (dalemiq@vlad.ru, nika1204@mail.ru, or call to the Vladivostok office at: 7-4232-41-00-33).

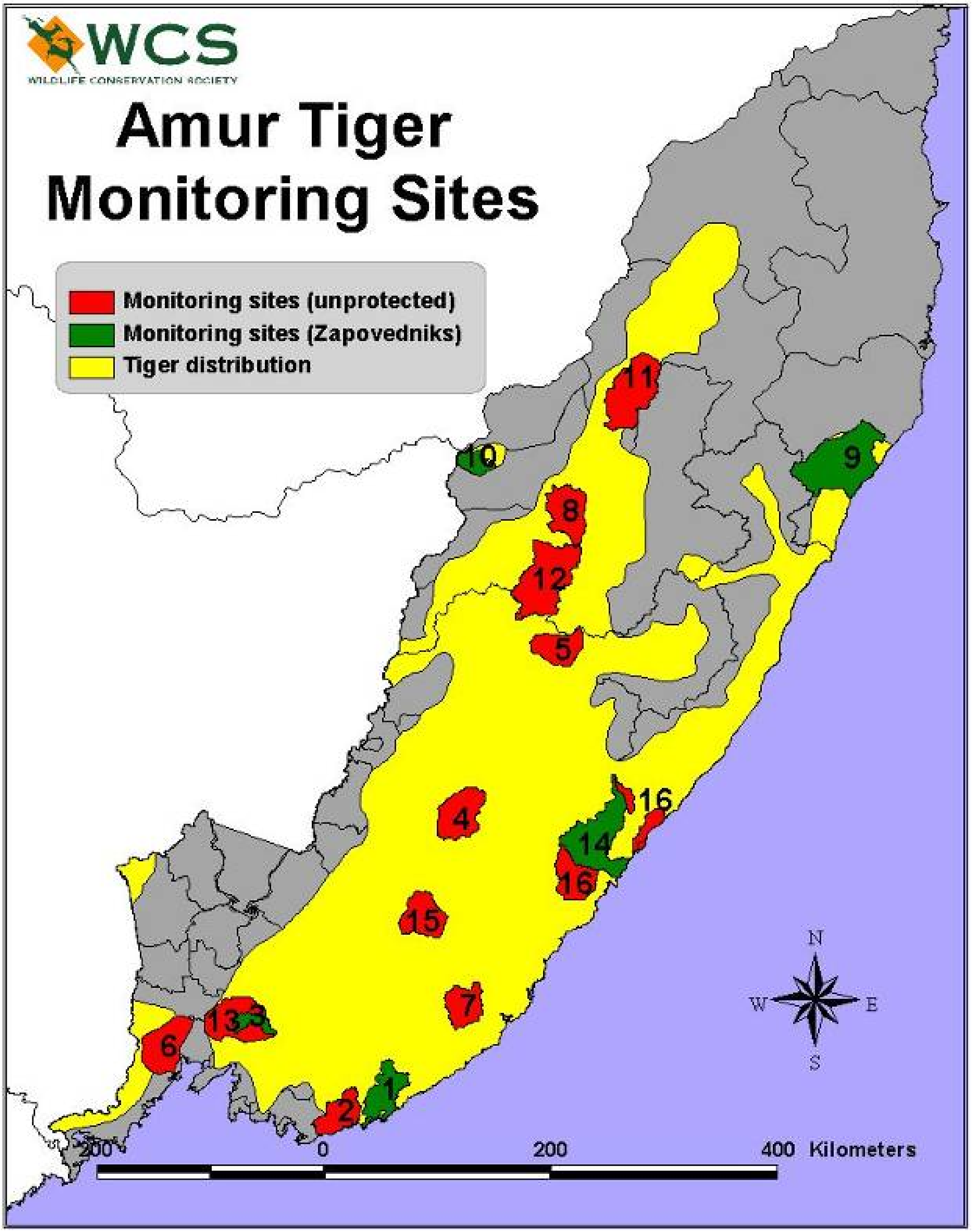


Figure 1. Location of the 16 sites used for monitoring Amur tigers in the Russian Far East. Numbers referenced in Table 1 and most other tables throughout text.

IV. RESULTS OF THE 2006-2007 WINTER MONITORING PROGRAM

Summary Data on Count Units and Routes

As in previous years, in the 2006-2007 winter the total area included in monitoring units was 23,555 km^2, or approximately 15-18% of the total area considered suitable tiger habitat, assuming either 156,571 (Matyushkin et al. Table 4) or 127,693 km^2 (Miquelle et al. 1999, Table 19.3) of suitable habitat.

A total of 246 survey routes were sampled (in nearly all units they were sampled twice), representing 3057 km of routes (with double sampling, a total of 6114 km traversed) (Table 1).

Table 1. Characteristics of units surveyed for Amur tiger monitoring program, 2006-2007.

	Monitoring Unit	Coordinator	Size of unit (km^2)	# survey routes	Total length of survey routes (km)	Average length of survey routes (km)	Survey route density (km/10 km2)
1	Lasovski Zapovednik	Salkina, G. P.	1192.1	12	121.4	10.1	1,02
2	Laso Raion	Salkina, G. P.	987.5	11	138.9	12.6	1,41
3	Ussuriski. Zapovednik	Abramov, V. K.	408.7	11	104.4	9.5	2,55
4	Iman	Nikolaev. I. G.	1394.3	12	176.9	14.7	1,27
5	Bikin	Pikunov, D. G.	1027.1	15	188.4	12.6	1,83
6	Borisovkoe Plateau	Pikunov, D. G.	1472.9	14	216.8	15.5	1,47
7	Sandago	Aramilev, V. V.	975.8	16	218.5	13.7	2,24
8	Khor	Dunishenko, Yu. M.	1343.8	19	190.3	10	1,42
9	Botchinski Zapovednik	Dunishenko, Yu. M.	3051	14	164.7	11.8	0,54
10	BolsheKhekhtsir Zapovednik	Dunishenko, Yu. M.	475.6	7	82.9	11.8	1,74
11	Tigrini Dom	Dunishenko, Yu. M.	2069.6	14	181.8	12	0,88
12	Matai	Dunishenko, Yu. M.	2487.6	24	372	15.5	1,50
13	Ussuriski Raion	Abramov, V. K.	1414.3	12	178.2	14.9	1,26
14	Sikhote Alin Zapovednik	Smirnov, E. N.	2372.9	26	277.7	10.7	1,17
15	Sineya	Fomenko, P. V.	1165.4	15	207.2	13.8	1,78
16	Terney Hunting Society	Smirnov, E. N.	1716.5	24	247.2	10.3	1,44
	Totals		23555,1	246	3057,3	12,43	1,30

Measures of Tiger Abundance

Presence/Absence on Survey Routes

Reporting on zero counts on survey routes serves two purposes.

1) From a methodological perspective large numbers of zero counts are not desirable because they reduce our capacity to detect changes in tiger numbers, i.e., if a survey route never has an occurrence of tiger tracks reported, it does not provide information on changes in tiger numbers. Therefore, understanding the distribution of zero counts is an important component of understanding the effectiveness of the sampling design.

2) Presence/absence is used as one of three indicators used to assess abundance (in this case, relative abundance) of tigers in each monitoring unit by ranking monitoring sites based on the percentage of routes without tiger tracks.

We report the proportion of survey routes with tiger tracks recorded on either the early or late winter surveys. In the 2007 winter on 56% of 246 routes on monitoring sites tiger tracks were reported (Table 2), the lowest ever reported (10-year average = 65.7%). As an average across all sites, this value has fluctuated only slightly over the ten years of monitoring (Figure 2), but 2007 was the first year this value dropped below 60%.

Most monitoring units (12 of 16) showed no clear trends or changes in the percentage of routes with tiger tracks. However, where there were trends, they were all in a downward direction (Figure 2). Ussuriski Zapovednik reported an extremely low encounter rate of tracks (Figure 3): whereas in past years tracks were reported on no less than 73% of routes, in 2007 tracks were reported on only 27%. While this instance may be an anomaly, we should pay attention to other indicators of tigers for Ussuriski Zapovednik and pay particular attention in future years as well. The monitoring unit in the Iman region has a non-significant downward trend (Figure 3), but again, is a site worth paying attention to. The monitoring site in the Khor Basin of Khabarovski Krai has shown a significant downward trend since 2000 (Figure 3). Again, comparisons are needed to determine if this pattern is consistent across all indicators.

Table 2. Percentage of routes with tiger tracks (occupancy) based on two winter surveys per year, 1998-2007 on survey units of the Amur Tiger Monitoring Program.

	YEAR										
Survey unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Lazovski Zapovednik	91.7	83.3	100.0	100.0	100.0	91.7	91.7	91.7	100.0	91.7	94.2
Lazovski Raion	100.0	72.7	63.6	45.5	90.9	90.9	81.8	45.5	100.0	90.9	78.2
Ussurisk Zapovednik	90.9	100.0	90.9	90.9	81.8	81.8	72.7	72.7	100.0	27.3	80.9
Iman	91.7	66.7	75.0	91.7	75.0	58.3	83.3	58.3	83.3	50.0	73.3
Bikin	53.8	87.5	87.5	93.8	81.3	81.3	75.0	68.8	75.0	87.5	79.1
Borisovskoe Plateau	57.1	57.1	50.0	57.1	50.0	64.3	50.0	57.1	100.0	64.3	60.7
Sandagoy	43.8	68.8	43.8	56.3	18.8	81.3	37.5	68.8	87.5	75.0	58.1
Khor	52.6	31.6	89.5	57.9	68.4	57.9	47.4	47.4	26.3	31.6	51.1
Botchinski Zapovednik	64.3	57.1	85.7	100.0	64.3	78.6	42.9	85.7	71.4	71.4	72.1
Bolshekhekhtsirki Zapovednik	85.7	42.9	85.7	14.3	28.6	28.6	42.9	57.1	14.3	0.0	40.0
Tigrini Dom	50.0	64.3	71.4	78.6	64.3	71.4	85.7	92.9	35.7	64.3	67.9
Mataiski Zakaznik	56.5	79.2	50.0	58.3	75.0	70.8	79.2	91.7	66.7	54.2	68.2
Ussuriski Raion	66.7	33.3	100.0	33.3	58.3	58.3	75.0	58.3	75.0	25.0	58.3
Sikhote Alin Zapovednik	88.0	80.0	84.0	76.0	64.0	80.0	48.0	52.0	72.0	80.0	72.4
Sineya	46.7	53.3	46.7	46.7	26.7	60.0	60.0	60.0	66.7	60.0	52.7
Terney Hunting Lease	66.7	66.7	54.2	60.9	34.8	45.8	13.6	35.0	36.4	26.1	44.0
Average	69.1	65.3	73.6	66.3	61.4	68.8	61.7	65.2	69.4	56.2	65.7

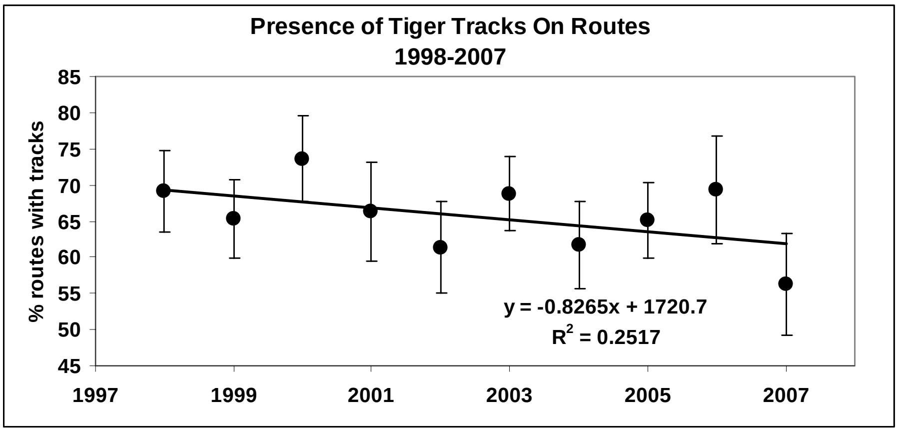


Figure 2. Overall trends in presence of tiger tracks on routes, averaged for all 16 sites of the Amur Tiger Monitoring Program, from the 1998 through 2007 winter seasons.

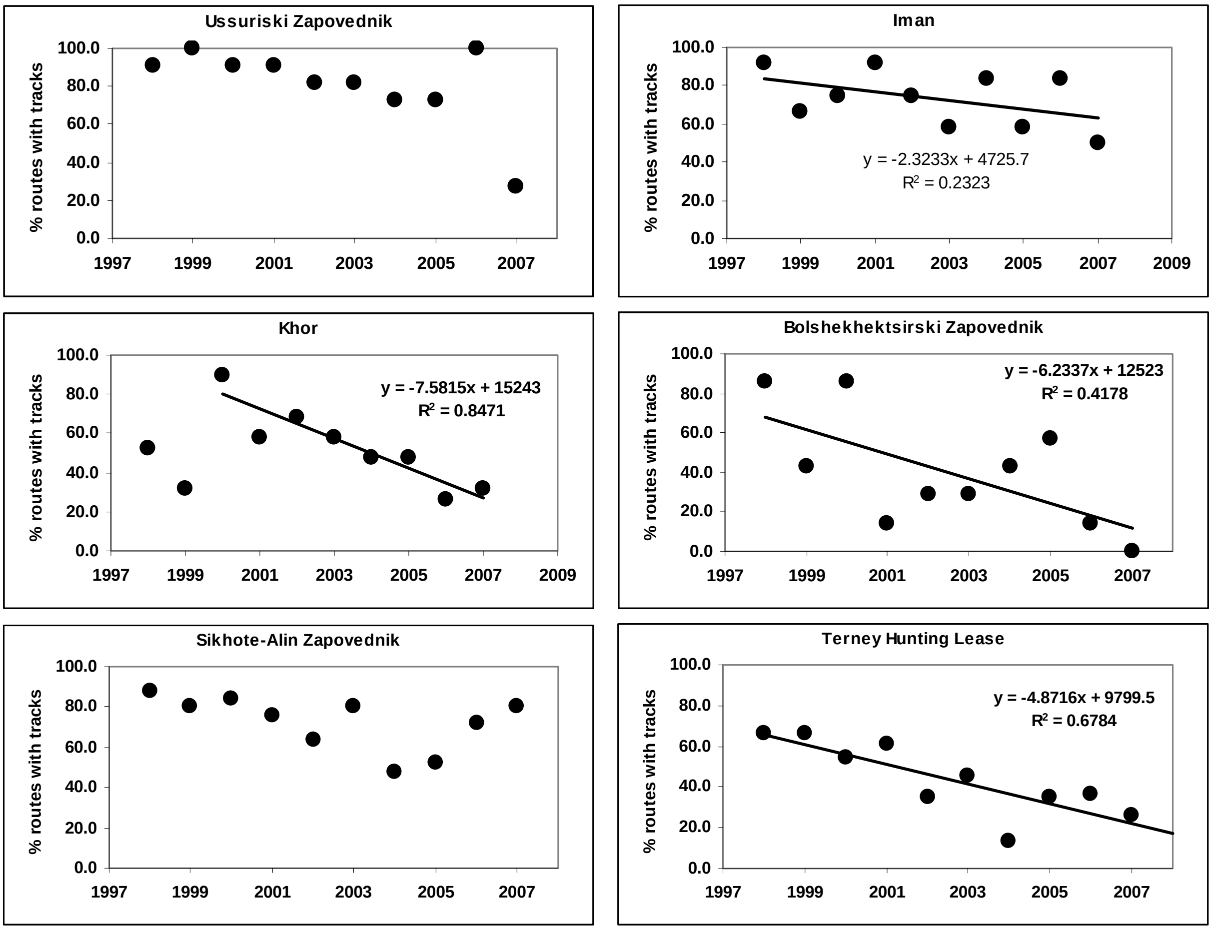


Figure 3. Trends in the percentage of survey routes with tiger tracks found for specific units of the Amur Tiger Monitoring Program, 1998 through 2007 winter seasons.

Based on the absence of tracks on routes alone in Bolshekhekhtsirski Zapovednik, it appears that tigers have gone locally extinct there (Figure 3). In Sikhote-Alin Zapovednik, where all indicators suggested that tiger numbers were decreasing there, the percentage of routes with tracks has increased since 2005 (Figure 3), providing hope that this negative trend may be reversing. However, in the neighboring Terney Hunting lease the percentage of routes with tiger tracks continues to remain low.

Track Counts on Survey Routes

Mean track density, adjusted for the number of days since the last snowfall (see Methods), provides an indication of relative abundance of tigers on monitoring sites (Table 3). Although the regression is not statistically strong, there are indications that, averaged across all sites, tiger track densities are decreasing (Figure 4). Track densities in 2007, which averaged only 0.88 tracks/100km/days since snow, are lower than the 10-year average (1.36) and are the lowest reported over the 10-year monitoring period. These data provide strong indications that the tiger population may be decreasing in the Russian Far East.

Although track density averaged for all years is highest in Ussurisk Zapovednik (Table 3), in 2007 there was an extremely low track density there, in agreement with the report of low percentage of routes with tracks (Table 2). In place of Ussuriski Zapovednik, Lazovski Zapovednik had the high track density estimate in 2007 (3.47), a value very close to its 10-year average (3.16)

The only monitoring unit where there is a suggestion of increases in track densities is in Sineya monitoring unit, in Olginski Raion (Figure 6). Five other units, including Lazovski Zapovednik, Lazovski Raion, Sandagoy, Borisovkoe Plateau, and Mataiski Zakaznik, show no clear trend.

The majority of units (ten) have decreasing trends in tiger track densities (Figure 6). Patterns vary amongst these units, as does the strength of the relationship, but collectively the information provides strong suggestions of a decline in tiger track densities across the range of tigers. In Ussuriski Zapovednik and the adjacent raion, the decline appeared to begin around 2000, as it does in the Khor unit (Figure 6). In Sikhote-Alin Zapovednik and the surrounding Terney Hunting Lease, tiger track densities seem to have decreased steadily across all years, with a possible slight upturn in 2007 in the zapovednik. In other sites, decreases appear to have started only recently (e.g. Tigrini Dom in 2005), while in Bolshekhekhtsirski Zapovednik, no tracks were reported on routes for the first time since monitoring began.

Table 3. Track densities (tracks/10 km/last snowfall) based on two winter surveys per year, 1998-2007 on survey units of the Amur Tiger Monitoring Program.

	Year										
Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Lazovski Zapovednik	3.62	2.19	3.01	3.57	2.52	3.50	4.15	2.13	3.44	3.47	3.16
Lazovski Raion	1.44	0.67	0.99	1.02	1.62	0.93	1.34	0.44	1.32	1.65	1.14
Ussurisk Zapovednik	3.28	9.66	6.21	6.15	3.49	2.62	2.12	2.71	4.20	0.26	4.07
Iman	0.96	2.81	0.86	0.76	0.81	0.65	0.51	0.64	0.63	0.30	0.89
Bikin	3.61	7.71	0.95	3.70	2.31	2.63	6.34	0.61	2.20	1.24	3.13
Borisovskoe Plateau	0.50	0.85	1.45	0.60	0.51	1.17	0.71	0.74	1.23	0.29	0.81
Sandagoy	0.48	0.66	0.34	0.41	0.23	0.83	0.40	0.39	0.67	1.22	0.56
Khor	0.44	0.80	1.67	1.50	1.35	0.45	1.05	4.17	0.26	1.21	1.29
Botchinski Zapovednik	0.88	0.74	1.20	1.29	1.04	0.46	0.58	0.77	0.81	0.66	0.84
Bolshekhekhtsirki Zapovednik	1.99	0.87	0.84	0.71	0.71	0.42	7.14	1.81	0.26	0.00	1.48
Tigrini Dom	0.67	1.47	1.13	1.51	1.66	1.27	2.21	1.51	0.31	0.95	1.27
Mataiski Zakaznik	0.63	1.18	0.73	2.42	0.38	0.39	0.59	2.46	0.53	0.52	0.98
Ussuriski Raion	1.01	0.61	1.93	1.44	1.70	0.52	0.72	0.46	0.96	0.18	0.95
Sikhote Alin Zapovednik	1.99	1.28	1.52	1.18	0.91	1.04	1.06	0.91	0.93	1.17	1.20
Sineya	0.24	0.33	0.47	0.58	0.38	0.58	0.86	0.57	1.76	0.69	0.65
Terney Hunting Lease	0.83	0.64	0.73	0.90	0.39	0.61	0.15	0.40	0.27	0.25	0.52
Average	1.41	2.03	1.50	1.73	1.25	1.13	1.87	1.29	1.24	0.88	1.43

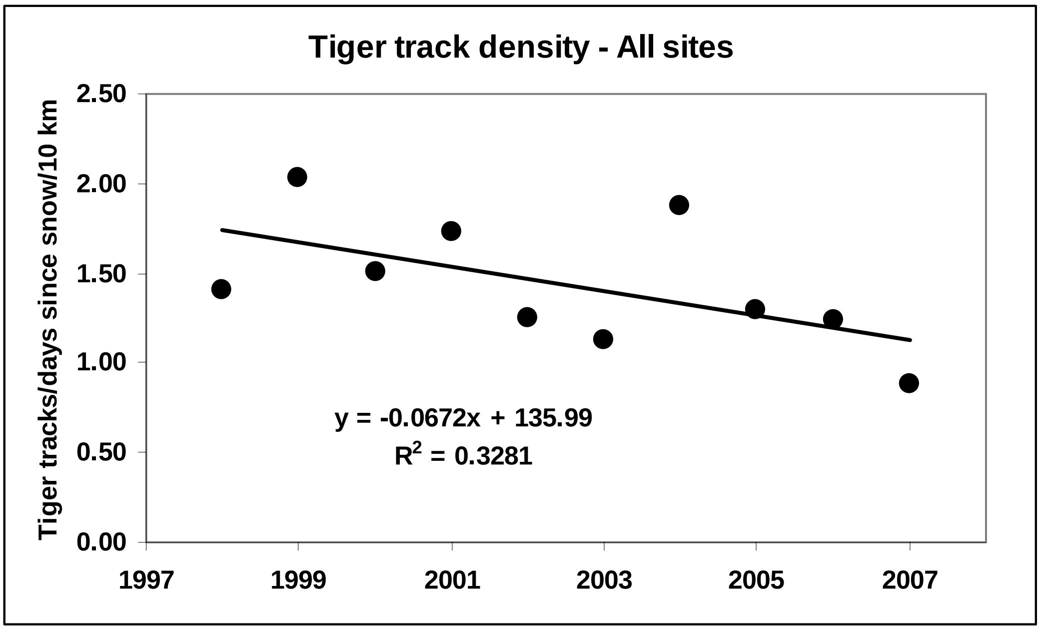


Figure 4. Density of tiger tracks (tracks/100 km/days since last snow) as an indicator of relative tiger abundance averaged across 16 sites included in the Amur Tiger Monitoring Program, winter 1998 through 2007.

To assess the magnitude of the shift in tiger track densities, we averaged track density for the first and second 5-year periods of the monitoring program, and subtracted the first from the second for each unit. If tiger track densities are decreasing, a larger percentage of these differences should be negative, which is in fact that case (Figure 5). In only three cases the differences between the first and second five years is nearly zero (Borisovkoe Plateau, Lazovski Raion, and Tigrini Dom). Overall, ten of the sixteen sites are negative, suggesting track densities have decreased across the majority of the monitoring units.

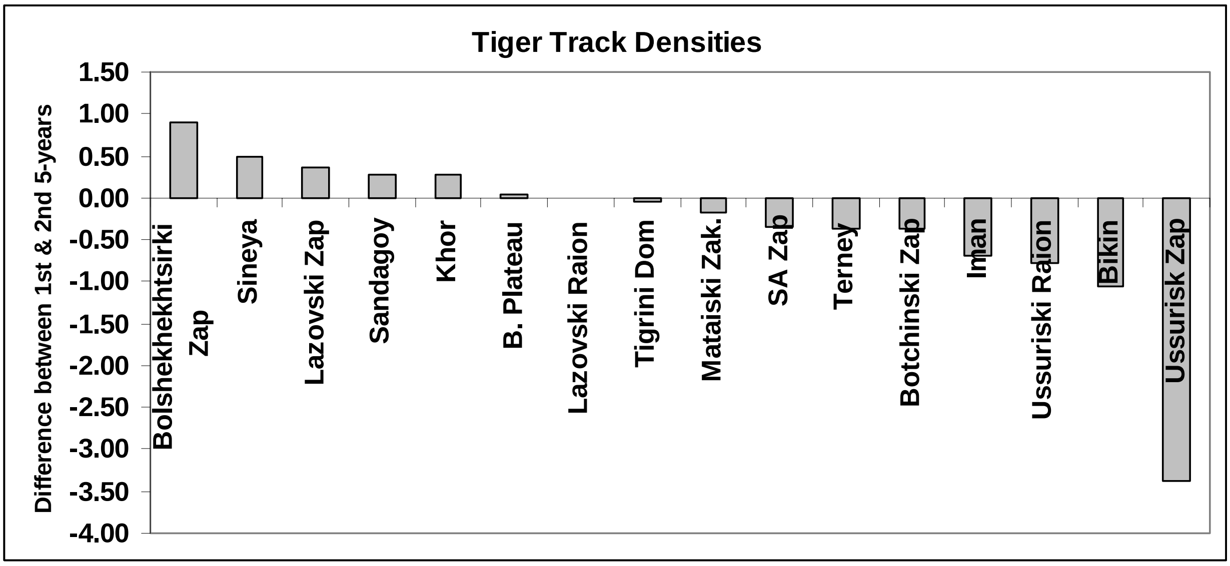


Figure 5. Differences in mean track densities between first and second 5 years of the Amur Tiger Monitoring Program 1998-2007.

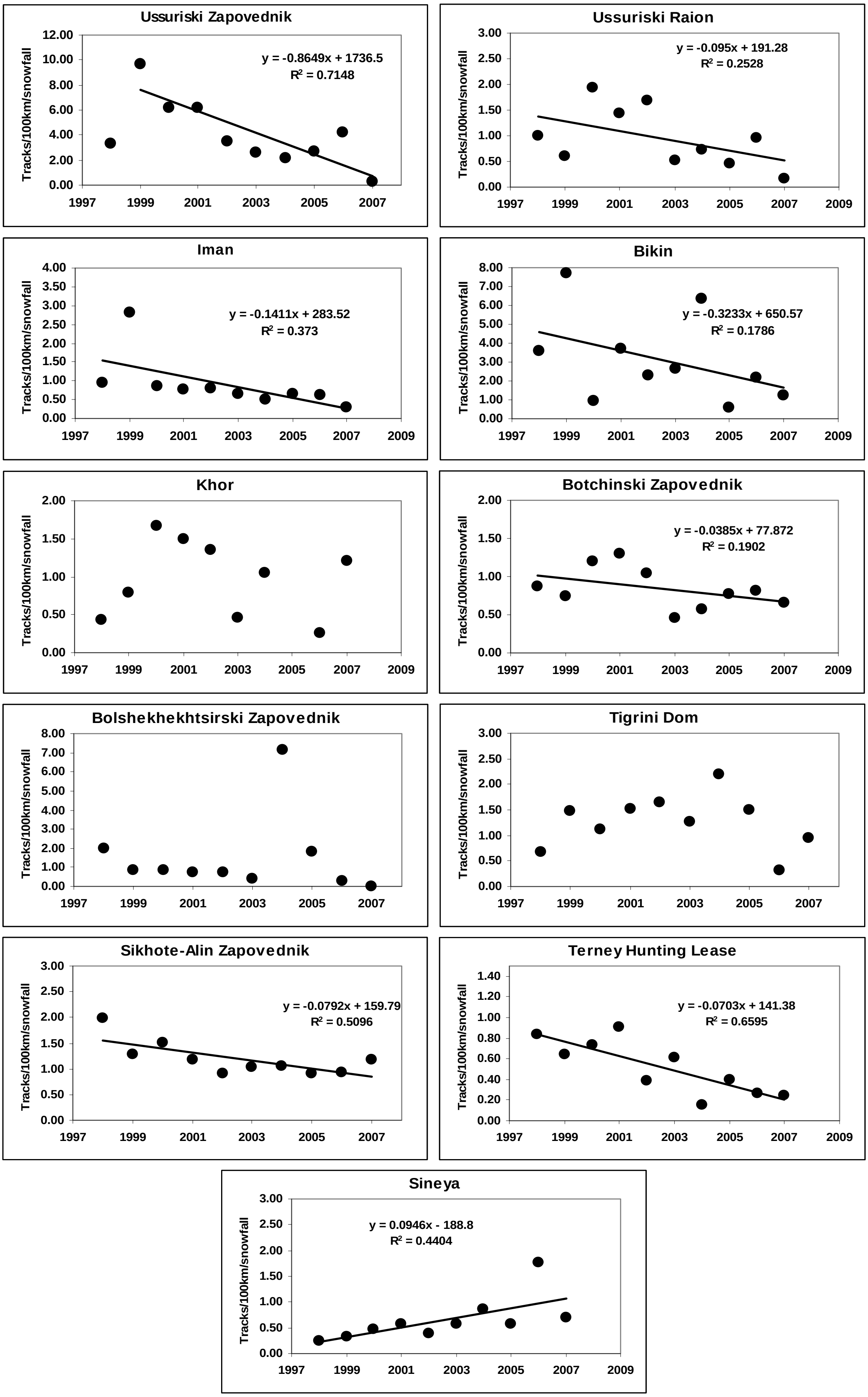


Figure 6. Track density (tracks/100 km/days since last snow) and trends for 11 of the 16 sites of the Amur Tiger Monitoring Program

Expert Assessment of Tiger Numbers on Monitoring Sites

We maintain consistency in having the same coordinators make expert assessments on each of the 16 monitoring units across the range of Amur tigers in the Russian Far East. In 2004 V.K. Abramov passed away, and two monitoring units (Ussuriski Zapovednik and Ussuriski raion) have been coordinated by his assistant, M. Litvinov. In Sikhote-Alin Zapovednik E.N. Smirnov retired in 2006, so responsibilities for monitoring tigers were shifted over to O. Zaumyslava in the Zapovednik. Although there is known to be variation among coordinators in how they interpret track data to estimate tiger numbers, there was a strong relationship between how all coordinators of the 2005 tiger survey (who are mostly the same people who do yearly monitoring) interpreted tiger tracks, and interpretation done by a standardized algorithm (Miquelle et al. 2007). Because of consistency in personnel, we believe that the year to year estimates within any given unit are likely to be consistent, assuming coordinators interpret track data in the same manner each year. While the variation among coordinators (and therefore among sites) is more difficult to account for, we believe providing estimates of tiger abundance across all sites provides a mechanism for comparing density across the range of tigers.

Table 4. Number of independent tigers (adults, subadults, and unknown) based on expert assessments of tiger tracks on 16 sites in the Russian Far East Amur Tiger Monitoring Program, 1998-2007.

Monitoring Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Lazovski Zapovednik	6	9	10	11	12	9	10	13	14	13	107
Lazovski Raion	8	4	5	4	6	5	4	8	6	6	56
Ussurisk Zapovednik	6	10	4	5	4	6	7	10	6	6	64
Iman	8	6	5	6	6	4	5	8	5	4	57
Bikin	3	10	7	6	7	8	5	5	12	9	72
Borisovskoe Plateau	4	5	4	3	3	5	3	3	3	7	40
Sandagoy	6	6	5	7	3	7	5	6	7	7	59
Khor	3	4	4	4	4	5	5	5	6	4	44
Botchinski Zapovednik	3	3	4	4	6	4	2	5	4	3	38
Bolshekhekhtsirki Zapovednik	2	1	2	1	1	1	2	2	1	1	14
Tigrini Dom	4	6	4	4	5	6	5	7	4	5	50
Mataiski Zakaznik	3	5	4	4	5	5	5	9	9	5	54
Ussuriski Raion	6	1	2	2	9	6	5	8	5	3	47
Sikhote Alin Zapovednik	21	21	23	17	17	16	12	19	16	27	189
Sineya	5	6	5	7	5	7	5	6	6	7	59
Terney Hunting Lease	10	11	13	11	5	7	3	8	6	8	82
Total	98	108	101	96	98	101	83	122	110	115	1032

Table 5. Density of independent tigers (adults, subadults, and unknown tigers/100 km2) based on expert assessments of tiger tracks on 16 sites in the Russian Far East Amur Tiger Monitoring Program, 1998-2007.

Monitoring Unit	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Average**
Botchinski Zapovednik	0.098	0.098	0.131	0.131	0.197	0.131	0.066	0.164	0.131	0.098	0.125
Mataiski Zakaznik	0.121	0.201	0.161	0.161	0.201	0.201	0.201	0.362	0.362	0.201	0.217
Bolshekhekhtsirki Zapovednik	0.421	0.210	0.421	0.210	0.210	0.210	0.421	0.421	0.210	0.210	0.294
Ussuriski Raion	0.424	0.071	0.141	0.141	0.636	0.424	0.354	0.566	0.354	0.212	0.332
Tigrini Dom	0.193	0.290	0.193	0.193	0.242	0.290	0.242	0.338	0.193	0.242	0.242
Iman	0.574	0.430	0.359	0.430	0.430	0.287	0.359	0.574	0.359	0.287	0.409
Khor	0.223	0.298	0.298	0.298	0.298	0.372	0.372	0.372	0.446	0.298	0.327
Terney Hunting Lease	0.583	0.641	0.757	0.641	0.291	0.408	0.175	0.466	0.350	0.466	0.478
Borisovskoe Plateau	0.272	0.339	0.272	0.204	0.204	0.339	0.204	0.204	0.204	0.475	0.272
Sineya	0.429	0.515	0.429	0.601	0.429	0.601	0.429	0.515	0.515	0.601	0.506
Lazovski Raion	0.810	0.405	0.506	0.405	0.608	0.506	0.405	0.810	0.608	0.608	0.567
Sandagoy	0.615	0.615	0.512	0.717	0.307	0.717	0.512	0.615	0.717	0.717	0.605
Bikin	0.292	0.974	0.682	0.584	0.682	0.779	0.487	0.487	1.168	0.876	0.701
Lazovski Zapovednik	0.503	0.755	0.839	0.923	1.007	0.755	0.839	1.091	1.174	1.091	0.898
Sikhote Alin Zapovednik	0.885	0.885	0.969	0.716	0.716	0.674	0.506	0.801	0.674	1.138	0.796
Ussurisk Zapovednik	1.468	2.447	0.979	1.223	0.979	1.468	1.713	2.447	1.468	1.468	1.566
Total	0.494	0.573	0.478	0.474	0.465	0.510	0.455	0.639	0.558	0.562	0.521

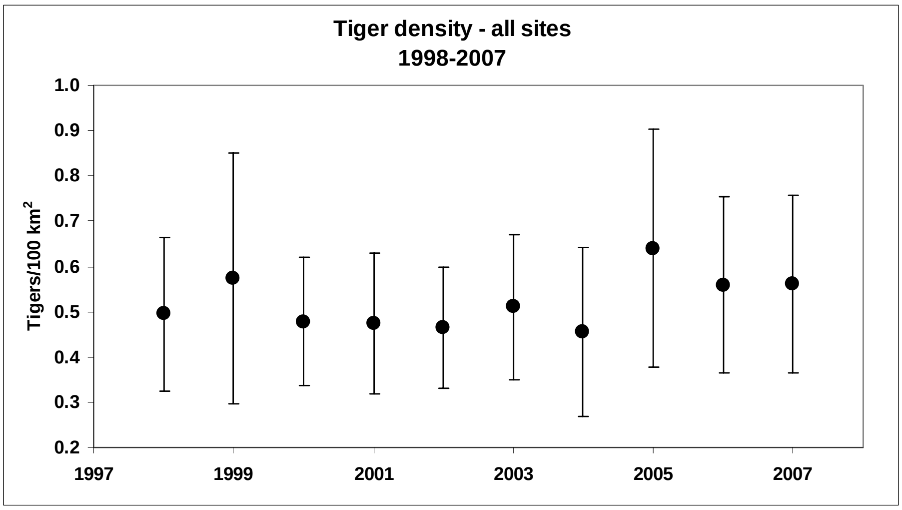


Figure 7. Density of independent tigers (adults and subadults) counted on monitoring units, based on expert assessments for 16 sites in the Amur Tiger Monitoring Program, 1998 through 2007.

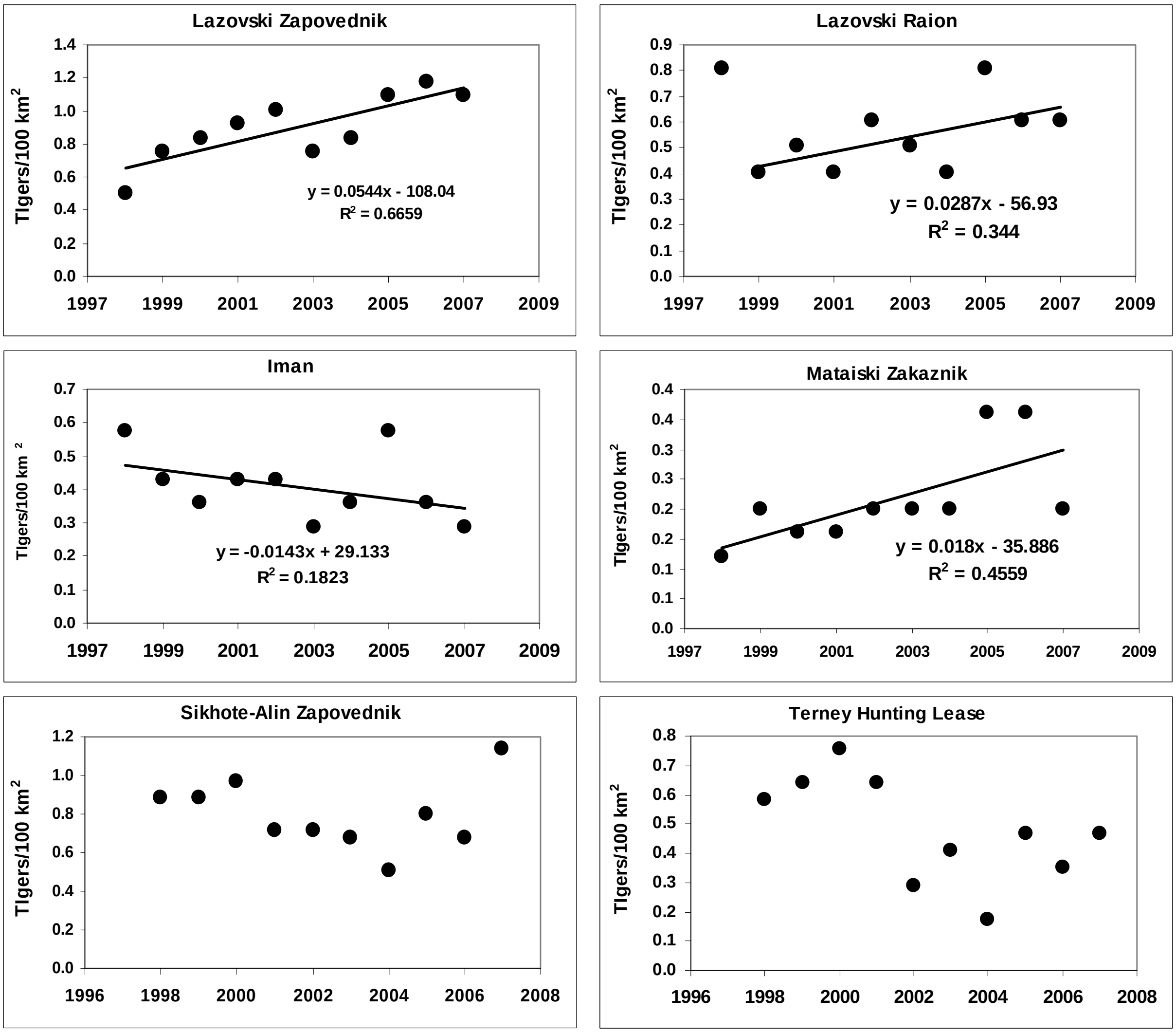


Figure 8. Tiger densities (adult tigers/100 km^2) in 6 of the 16 monitoring units of the Amur Tiger Monitoring Program, winters 1998 through 2007.

The 115 adult tigers reported on all 16 sites combined is slightly more than the 10-year average (110.3) (Table 4). Overall tiger densities appear to be very similar to the previous year, but lower than a high estimate in 2005 (Figure 7).

Tiger density averaged across all sites was 0.56/100 km^2, very similar to the 10-year average of 0.52/100 km^2. Variations in estimates of tiger densities have been relatively minor; overall, suggesting that tiger density appears to be fairly stable across all sites combined. However, tiger density varied ten-fold across monitoring units, from 1.47 animal/100 km^2 in Ussuriski Zapovednik (which has been consistently the monitoring site with highest densities across nearly all years) (Table 5), to 0.09/100 km^2 in Botchinski Zapovednik (Table 5).

The three southern and central zapovedniks (Ussuriski, Lazovski, and Sikhote-Alin) have retained the highest 10-year average densities (Table 5), indicating the importance of protected areas in tiger conservation strategies. As expected, 5 of the 6 monitoring sites with the lowest tiger densities are in Khabarovski Krai, reflecting the harsher conditions in this most northern distribution of tigers.

Although expert assessments of tiger densities appeared to be stable when averaged across all sites, individual sites continue to show a range of trends in 2007. In contrast to the occupancy and track density estimates, some tiger densities based on expert assessments in some units appear to be increasing (Figure 8). Tiger density in Lazovski Zapovednik seems to be on the increase, and while the strength of the relationship is much weaker, there also appears to be increases in adjacent Lazovski Raion. Although there was a drop in tiger density in 2007, Matai Zakaznik in Khabarovsk also shows in increasing trend (Figure 8). Despite decreasing track densities in Sikhote-Alin Zapovednik and adjacent Terney Hunting lease, tiger densities based on expert assessments suggest that tiger numbers reached a low around 2004, and are now increasing (Figure 8).

Reproduction on Monitoring Sites

Expert assessments of tiger numbers and sex-age structure provide an opportunity to track changes in reproduction over time. Because tracks of young cubs with mothers are quite distinction, reporting on litters provides important information on reproduction across tiger habitat in Russia. However, interpretation of data can be difficult. Multiple sets of tracks on individual litters can result in inflated estimates if not properly interpreted, and cubs without mothers can also confuse interpretation. Therefore, correct identification of the number of litters, and total number of cubs, can be difficult. Nonetheless, the data collected over multiple years at multiple sites provides valuable insights into reproduction across the range of Amur tigers.

Since the 1997-1998 winter the number of litters reported on all sites combined has ranged from 12 to 23, and averaged 16.9 litters. In 2007, a total of 13 litters, well below the average, were reported. (Table 7, Figure 9). The total number of cubs reported for this year (18) was also below the 10-year average of 23.6 (Table 8). The percentage of monitoring units without cubs has ranged from 12.5 to 43.75%, with this past winter (2007), at 37.5%, again higher than the 10-year average of 30.6%. In general, these values suggest that reproduction across the range was below average for the 2007 winter monitoring period.

Total cub production on all 16 units appeared to have dropped through the first three years of monitoring, and then risen through 2002. Since 2002, cub production has dropped fairly consistently through 2007, which recorded the smallest number of cubs since 2000 (Figure 10). This drop may be simply a single event, but, on the other hand, in conjunction with decreasing prey numbers (see section on ungulates) may be indicative of more difficult times for tigers. This parameter merits close monitoring, as it is likely that reproduction rates will decrease before actual numbers of adult tigers decrease. A consistent decline in reproduction rates would be clear signal of trouble for the Amur tiger.

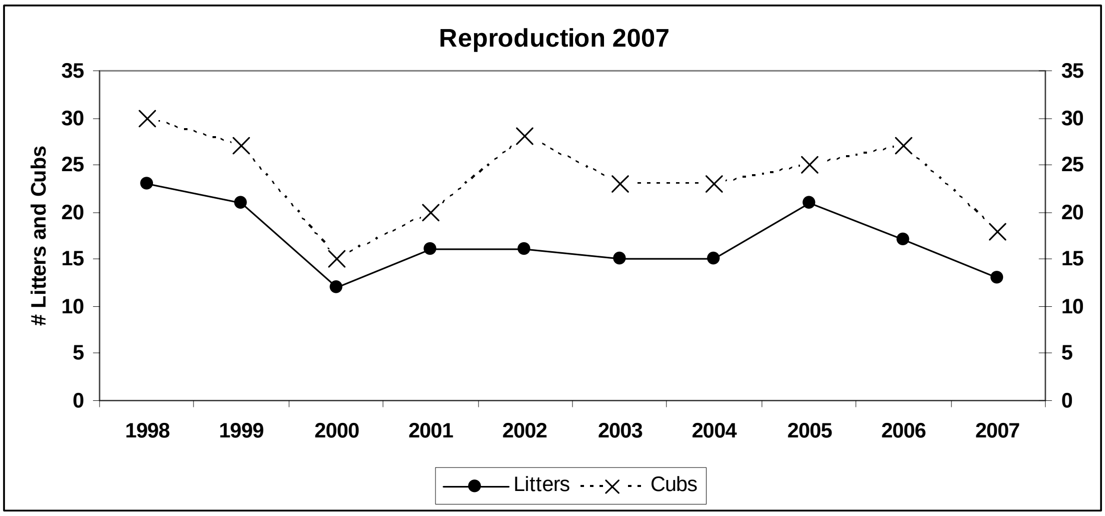


Figure 9. Total number of cubs and litters produced on all 16 units combined for the 10 winter seasons, 1998 through 2007, for the Amur Tiger Monitoring Program.

Table 7. Number of litters produced on each monitoring unit for 10 winters, 1998 through 2008, based on expert assessments of tiger tracks for the Amur Tiger Monitoring Program.

	Litter production										
Monitoring unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total litter production
Lazovski Zapovednik	1	1	0	2	2	3	1	2	4	1	17
Lazovski Raion	2	1	0	1	4	1	2	1	0	1	13
Ussurisk Zapovednik	2	3	1	1	1	2	2	2	3	0	17
Iman	0	1	1	1	1	0	0	1	0	1	6
Bikin	3	0	2	0	2	1	0	1	0	2	11
Borisovskoe Plateau	2	1	1	1	0	1	0	1	0	0	7
Sandagoy	3	1	0	0	1	0	1	1	0	1	8
Khor	1	1	0	1	1	0	1	1	1	2	9
Botchinski Zapovednik	1	1	2	1	0	0	1	1	1	0	8
Bolshekhekhtsirki Zapovednik	0	1	0	1	0	0	0	0	0	0	2
Tigrini Dom	0	1	1	1	1	1	1	0	1	0	7
Mataiski Zakaznik	2	2	1	0	1	4	2	2	1	2	17
Ussuriski Raion	0	1	0	0	0	1	1	1	1	1	6
Sikhote Alin Zapovednik	4	4	1	4	0	1	2	6	4	1	27
Sineya	1	0	1	1	1	0	1	1	0	0	6
Terney Hunting Lease	1	2	1	1	1	0	0	0	1	1	8
Totals	23	21	12	16	16	15	15	21	17	13	169

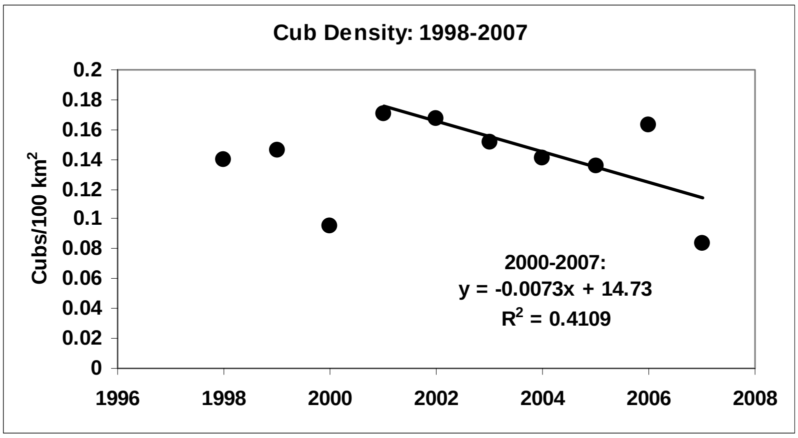


Figure 10. Cub density averaged across all sites of the Amur Tiger Monitoring Program.

Table 8. Number of cubs produced on each monitoring unit for 10 winters, 1998-2007, based on expert assessments of tiger tracks for the Amur Tiger Monitoring Program.

	Cub production										
Monitoring unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total cub production
Lazovski Zapovednik	2	2	0	5	4	6	3	3	8	2	35
Lazovski Raion	2	2	0	3	8	1	3	1	0	1	21
Ussurisk Zapovednik	2	3	3	2	2	5	4	3	5	0	29
Iman	0	2	2	2	1	0	0	1	0	2	10
Bikin	3	0	2	0	3	1	0	1	0	3	13
Borisovskoe Plateau	2	1	1	1	0	2	0	1	0	0	8
Sandagoy	4	1	0	0	2	0	1	1	0	1	10
Khor	1	1	0	1	1	0	1	3	1	2	11
Botchinski Zapovednik	1	1	2	2	0	0	2	1	1	0	10
Bolshekhekhtsirki Zapovednik	0	1	0	3	0	0	0	0	0	0	4
Tigrini Dom	0	1	1	1	1	1	1	0	1	0	7
Mataiski Zakaznik	3	2	2	0	1	4	3	2	1	2	20
Ussuriski Raion	0	2	0	0	0	1	2	1	2	2	10
Sikhote Alin Zapovednik	4	5	1	4	0	2	2	6	6	1	31
Sineya	1	0	1	3	3	0	1	1	0	0	10
Terney Hunting Lease	1	2	1	1	1	0	0	0	2	2	10
Totals	30	27	15	20	28	23	23	25	27	18	239

Table 9. L:itter size of all litters recorded in 10 winters of the Amur Tiger Monitoring Program, based on expert assessment of tracks.

	Litter size			
Year	1	2	3	Total
1998	20	3		23
1999	16	5		21
2000	9	2	2	13
2001	8	4	3	15
2002	7	7	2	16
2003	9	4	2	15
2004	8	6	1	15
2005	18	2	1	21
2006	8	8	1	17
2007	8	5		13
Total # litters	111	46	12	169
% of litters	65.7	27.2	7.1	

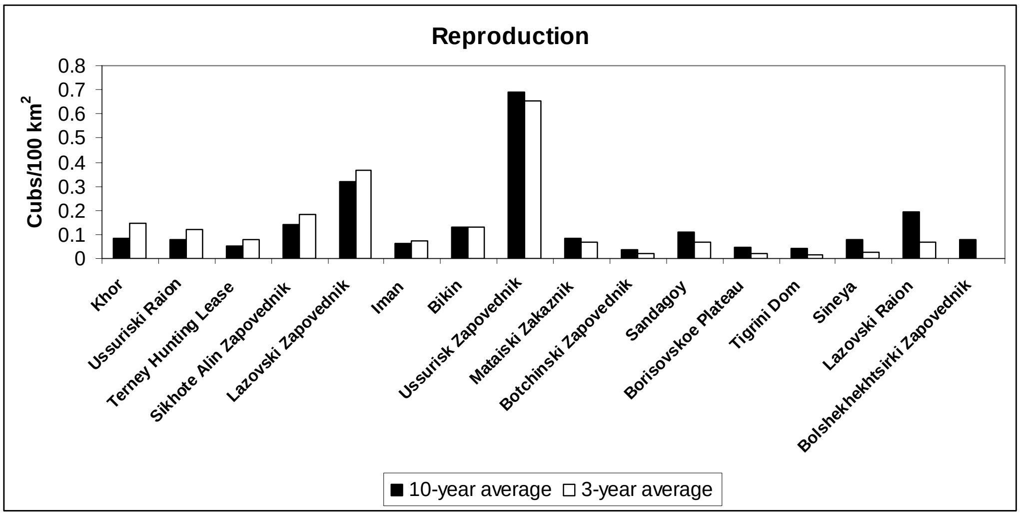


Figure 11. Cub density at each site, as a 10-year average (in black) and the average for the last three years (2005-2007 – in white), for the 2007 winter, across all monitoring sites of the Amur Tiger Monitoring Program for each of the 16 sites.

Estimation of productivity is difficult because sex ratios are often difficult to define in the adult population, but we can develop estimates of cub density to compare productivity across sites. For all years combined, there are dramatic differences between sites (Figure 11). Ussuriski Zapovednik appears to be far and away the most productive site, on average, but in 2007 no cubs were reported there, and across the last three years, productivity has been down compared to the 10-year average (Figure 11). However, this appears balanced by the fact that cubs were reported in the adjacent unit – Ussuriski raion – in increased numbers over the same period. Although cub density is low in the Khor site, over the past three years productivity has increased by 83% over the 10-year average (Figure 11). In general, cub density coincides with adult density, with cub density highest in the southern zapovedniks (Lazovski, Ussuriski, and Sikhote-Alin) and lowest in the Khabarovsk sites (e.g., Tigrini Dom, Botchinski Zapovednik). Interestingly, Borisovkoe Plateau has one of the lowest cub densities, despite having one of the highest densities of sika deer.

Ungulate Populations on Monitoring Sites

Red deer, wild boar, and sika deer are the primary prey of Amur tigers. Roe deer are taken relatively infrequently, and may be considered secondary prey. On occasion, even musk deer and moose are taken. Of these 6 species, only wild boar and roe deer are relatively common across most of tiger habitat in the Russian Far East. Moose occur only in the northern half of tiger range (and rarely show up in monitoring sites), and red deer are rare in the southern third of tiger range and now absent from Southwest Primorski Krai. Sika deer occur mostly in the southern third where red deer are uncommon, and in fact there appears to be an inverse relationship in the relative abundance of red deer and sika deer. The boundaries defining species distribution of all species are shifting quite remarkably, with the entire ecosystem "shifting" north: moose are becoming uncommon in the central Sikhote-Alin; sika deer are expanding rapidly to the north, and red deer also appear to be retreating in the face of sika deer expansion, especially along the eastern slopes of the Sikhote-Alin Range. These fluctuations which may be related to global climate change. But nonetheless, these fluctuations make interpretation of trends for ungulate populations more difficult. For instance, if red deer numbers are decreasing in a southern monitoring unit, this the result of high illegal harvest, or does it represent a response to increasing sika deer numbers. Thus we should be aware of changes in ungulate numbers, but at the same time be careful in making assumptions about the causes of those changes.

We used track density as an indicator of ungulate abundance on Amur tiger monitoring units. As in previous years, prey numbers varied greatly among sites (Table 10). To attempt to understand how density estimates varied across monitoring sites and time, we conducted a regression analysis to look for trends across time, looking first at trends for all sites combined, and then separately for each site and each species. We conducted trend analyses for the entire 10 years, or a subset of years where a visual inspection suggested a significant trend might exist. We report all sites where the probability is less than 0.2 that the slope is not zero, with the understanding that we are looking for general trends and potential early warning signs across the region and within each monitoring site.

Table 10. Mean track density (tracks/10 km of transect, sample size (number of routes) and standard error of the mean on 16 units of the Amur Amur Tiger Monitoring Program for 2007.

		Track density/10 km											
	#	Red deer		Wild boar		Sika deer		Roe deer		Musk deer		Moose	
Monitoring Unit	routes	Mean	Std Err	Mean	Std Err	Mean	Std Err	Mean	Std Err	Mean	Std Err	Mean	Std Err
1 Lazovski Zapovednik	12	3.71	1.90	6.17	5.35	67.87	21.78	0.67	0.41	0	0	0	0
2 Lazovski Raion	11	0.04	0.04	0.94	0.48	56.77	37.85	0.09	0.09	0	0	0	0
3 Ussurisk Zapovednik	11	7.21	2.93	3.27	1.38	14.80	7.55	1.81	0.62	0	0	0	0
4 Iman	12	3.04	1.11	1.03	0.49	0	0	3.46	1.21	0	0	0	0
5 Bikin	16	6.85	1.33	7.31	1.33	0	0	5.35	0.82	0.51	0.28	0	0
6 Borisovskoe Plateau	14	0.00	0.00	1.35	0.40	24.55	6.82	5.00	1.68	0.26	0.20	0	0
7 Sandagoy	16	2.30	1.17	0.66	0.19	1.75	0.45	2.55	0.53	0.31	0.25	0	0
8 Khor	19	3.30	0.68	4.57	1.26	0	0	1.80	0.75	0	0	0	0
9 Botchinski Zapovednik	14	0.79	0.24	0.00	0.00	0	0	0.60	0.22	0	0	0	0
10 Bolshekhekhtsirki Zapovednik	7	26.07	9.94	2.07	1.22	0	0	4.86	2.10	0	0	0	0
11 Tigrini Dom	14	1.41	0.43	0.17	0.10	0	0	0.13	0.13	0.10	0.07	0	0
12 Mataiski Zakaznik	24	1.98	0.67	0.48	0.15	0	0	1.03	0.38	0.17	0.06	0	0
13 Ussuriski Raion	12	3.48	1.64	4.44	2.10	1.00	0.41	4.84	2.35	0.10	0.10	0	0
14 Sikhote Alin Zapovednik	25	8.35	1.45	1.62	0.50	7.16	2.75	7.06	1.19	2.86	1.50	0	0
15 Sineya	15	0.67	0.21	0.51	0.13	0	0	1.04	0.21	0.07	0.04	0	0
16 Terney Hunting Lease	24	1.94	0.44	0.38	0.13	0.08	0.08	2.95	0.69	0.23	0.13	0	0

Red deer

For the past three years, red deer track densities, averaged over all sites except Borisovkoe Plateau (where they are absent) have been remarkably steady, remaining lower than all previous 6 years of monitoring (Table 11, Figure 13). However, the overall pattern masks some interesting developments and trends in different portions of tiger range.

As in past years, red deer track densities varied greatly among monitoring sites, from 26 tracks/10 km in Bolshekhekhtsirski Zapovednik to 0 in Borisovskoe Plateau, where they are no longer reported. And as in past years, track count densities of red deer were highest in Bolshe-Khekhtsirski Zapovednik, and secondly, in Sikhote-Alin Zapovednik (Table 10). However, red deer track densities have fallen dramatically in Sikhote-Alin Zapovednik, and now track densities are similar to that found in Ussuriski Zapovednik (Table 10). Thus, there remains only one of our monitoring sites - Bolshekhekhtsirski Zapovednik - where track densities of red deer remain high (> 22 tracks/10 km).

In our tenth year of monitoring we are now detecting disturbing trends for red deer, which is the main prey for tigers across most of the Russian Far East. While only one monitoring site has increasing numbers of red deer (Bolshekhekhtsirski Zapovednik – a small and well protected zapovednik close to the city of Khabarovsk), there are 6 sites that are demonstrated strong indications of decreasing numbers of red deer (Lazovski Raion, Bikin Tigrini Dom, Sikhote-Alin Zapovednik Terney Hunting Lease, and Sineya in Chuguevski Raion). Most of these trend lines are strong (i.e., $r^2 > 0.4$) and significant (Figure 14). Another trend is developing across many sites, in which we detect what appeared to be increasing numbers of red deer through 2001 or 2002, and then a sharp decline. This pattern is visible in the average of all monitoring sites (Figure 13), as well as for Lazovski Zapovednik, Iman, Sandagoy and Matai Zakaznik.

In many sites in southern Primorye, red deer numbers are disappearing or have already disappeared (Borisovkoe Plateau, Lazovski Raion, and Sineya). In some cases, as in Borisovkoe Plateau, it is possible that sika deer have been responsible for the decline in red deer numbers. However, in a previous report (2006) we demonstrated that sika deer numbers start to depress red deer numbers when sika deer densities approach 25 tracks/10 km. There are 4 sites where sika deer

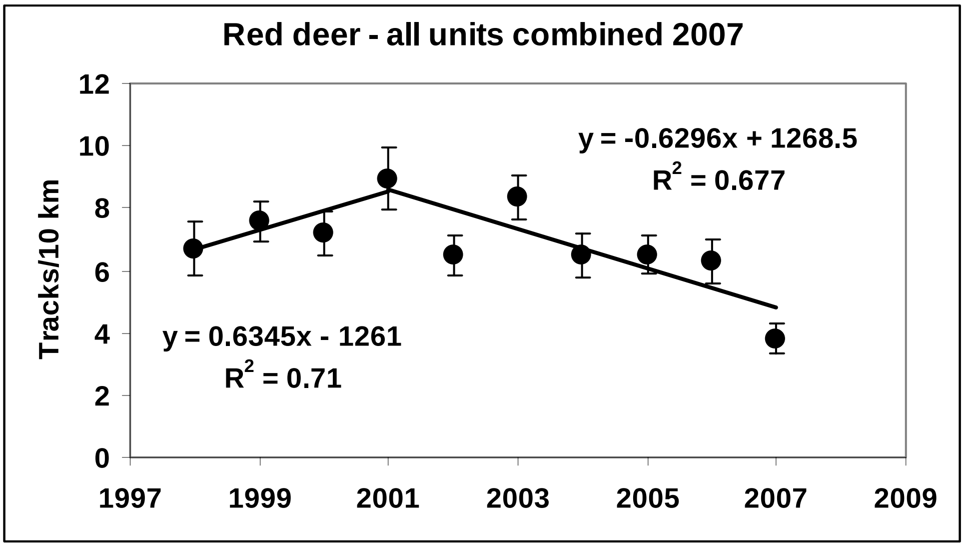


Figure 13. Average red deer track density and standard errors across all 16 sites for the ten years of the Amur Tiger Monitoring Program, 1998 though 2007.

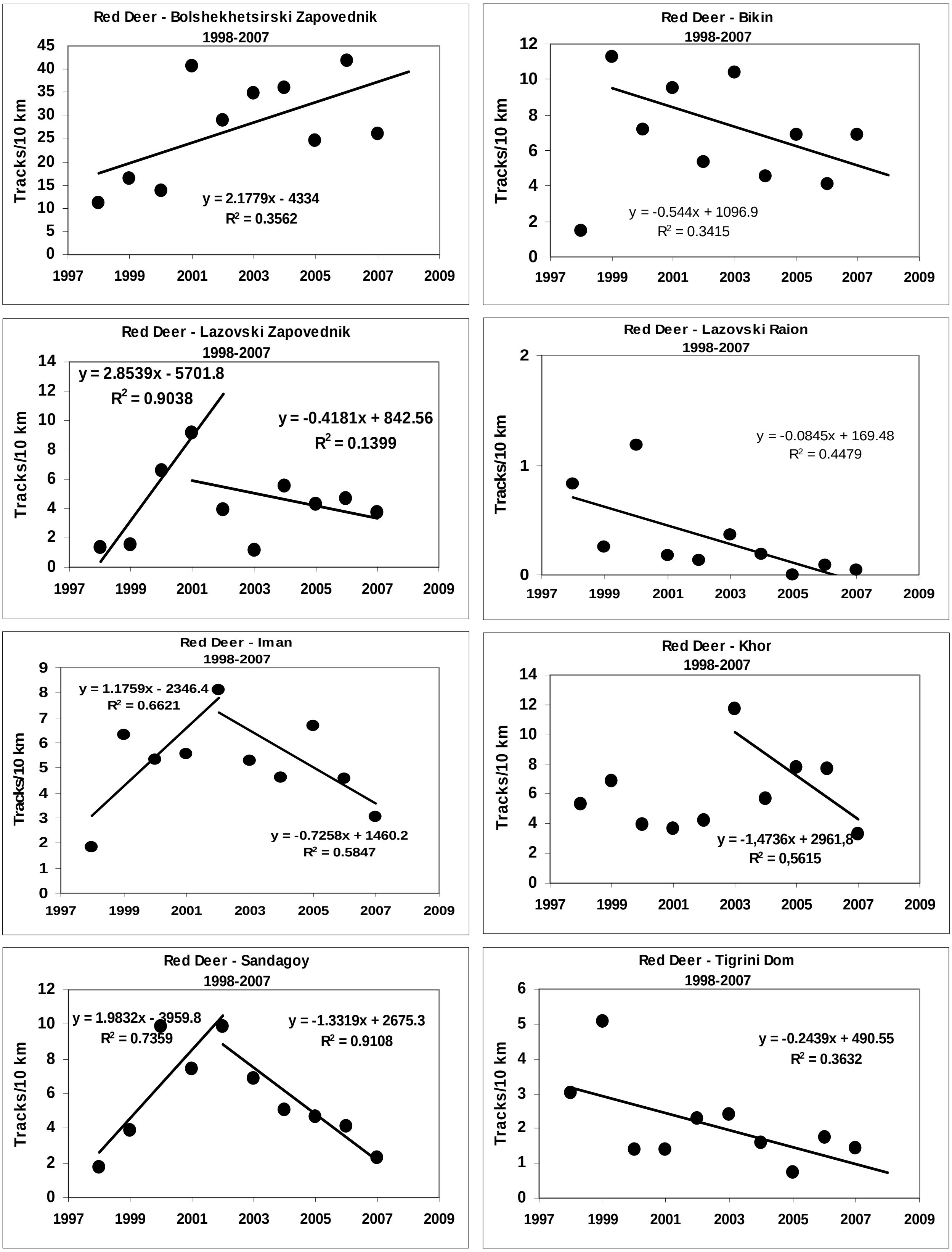
track densities exceed this critical level (Lazovski Zapovednik Ussuriski Zapovednik, Borisovkoe Plateau, and Lazovski Raion). Outside of these areas, declines in red deer numbers are more likely due to uncontrolled harvest by humans. The pattern of an increasing number of red deer through 2001 or 2002 followed by a decline is coincident with reorganization of the governmental bodies responsible for law enforcement of hunting regulations, and with a decline in their effectiveness. The decline in red deer numbers is likely a reflection of this reduced effectiveness in enforcing hunting regulations.

Hence, overall, the population of red deer across the region appears to be in decline. The reasons for the decline are partially attributable to increases in sika deer numbers (see next section), but an increase in illegal hunting is likely an even greater factor, and for the present, this last factor is the only one that can be reasonably addressed with management actions.

Table 11. Red deer track densities (tracks/10 km) on routes surveyed on 16 untis for the Amur Tiger Monitoring Program 1998-2007.

Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Lazovski Zapovednik	1.36	1.49	6.62	9.16	3.92	1.14	5.53	4.30	4.67	3.71	4.19
Lazovski Raion	0.83	0.25	1.18	0.18	0.14	0.36	0.18	0.00	0.08	0.04	0.33
Ussurisk Zapovednik	5.87	7.03	7.06	5.11	3.43	4.79	3.64	5.13	3.08	7.21	5.23
Iman	1.83	6.33	5.33	5.56	8.10	5.29	4.61	6.66	4.57	3.04	5.13
Bikin	1.47	11.24	7.14	9.53	5.32	10.37	4.52	6.91	4.13	6.85	6.75
Borisovskoe Plateau	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sandagoy	1.74	3.84	9.90	7.41	9.87	6.87	5.07	4.67	4.08	2.30	5.58
Khor	5.35	6.82	3.98	3.66	4.19	11.72	5.64	7.82	7.73	3.30	6.02
Botchinski Zapovednik	1.82	6.87	4.33	2.84	4.73	5.40	11.61	4.72	5.44	0.79	4.85
Bolshekhekhtsirki Zapovednil	11.01	16.29	13.63	40.57	29.00	34.79	35.93	24.50	41.66	26.07	27.35
Tigrini Dom	3.00	5.06	1.38	1.38	2.29	2.38	1.58	0.72	1.73	1.41	2.09
Mataiski Zakaznik	1.74	4.85	3.76	2.23	4.67	9.54	3.43	5.34	3.05	1.98	4.06
Ussuriski Raion	2.28	2.02	4.30	1.85	1.43	2.78	1.50	2.84	0.94	3.48	2.34
Sikhote Alin Zapovednik	32.55	23.98	23.98	32.82	19.41	21.29	20.35	21.74	20.48	8.35	22.49
Sineya	1.67	4.00	2.77	3.49	1.55	2.31	1.79	1.62	0.57	0.67	2.04
Terney Hunting Lease	13.69	10.11	9.27	13.94	6.16	9.87	3.96	4.26	5.15	1.94	7.83
Average	5.39	6.89	6.54	8.73	6.51	8.06	6.83	6.33	6.71	4.45	6.64

Figure 14, page 1.



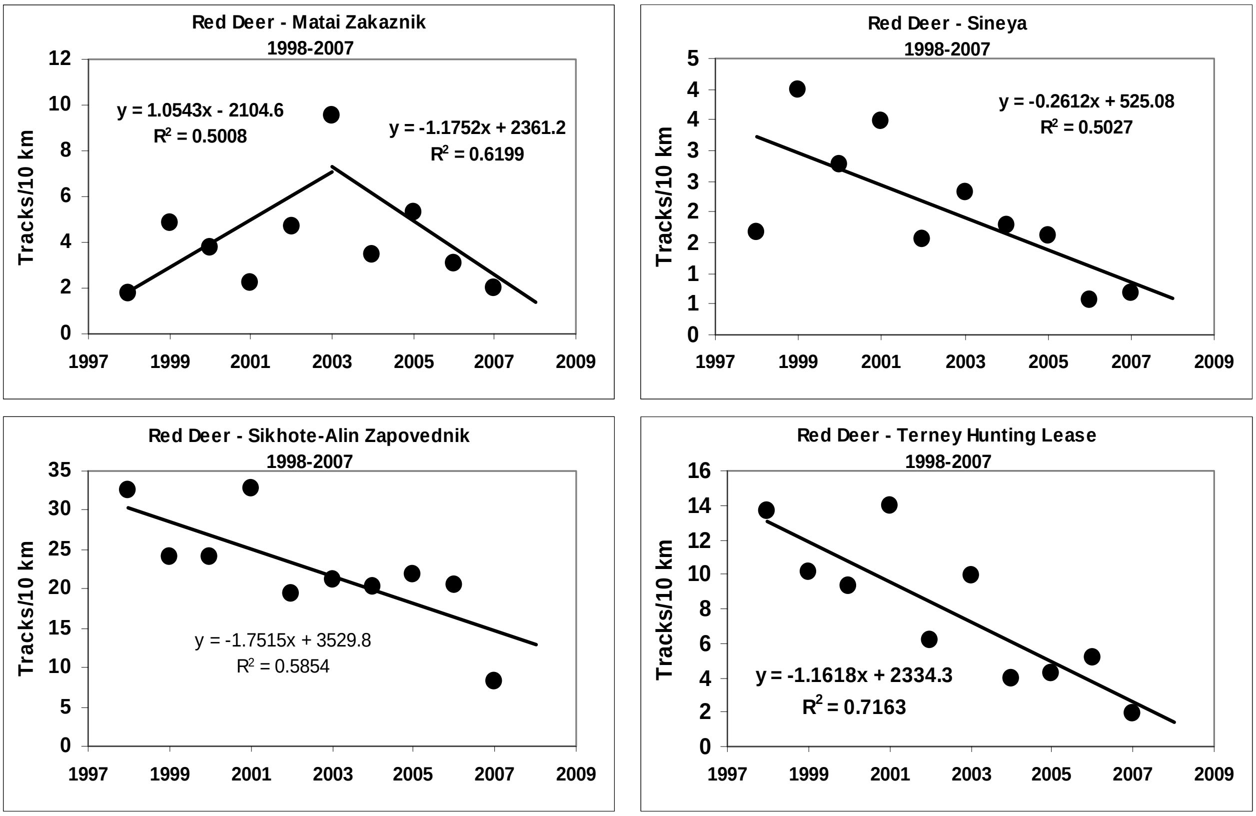


Figure 14. Changes ($p < 0.2$) in red deer densities, as measured by fresh tracks/10 km along routes in 12 of the 16 monitoring sites of the Amur Tiger Monitoring Program. Only one site showed positive trends; four sites had increasing numbers of red deer through 2002 or 2003 followed by declines, and seven show declines over 8 or 9 years.

Wild boar

Wild boar populations are known to fluctuate more dramatically than most deer populations, and because they are commonly found in groups, are more problematic to accurately estimate density.

Averaged across all sites, wild boar track densities appear to be decreasing over the past three years (Figure 15), although there does not appear to be any long term trends in population size. Wild boar track densities are generally lower than those of red deer (wild boar track density at all sites over 10 years = 3.75tracks/10 km, versus 6.6 tracks/10 km for red deer) but fluctuate more from site to site than those of red deer, apparently because they have the capacity to move large distances in search of winter forage. In 2007 winter, wild boar densities averaged 2.18 + 0.8 tracks/10 km, lower than the 10-year average (Table 12).

Unlike red deer or roe deer (see below), there does not seem to be any clear trends in wild boar numbers across the region. Similarly, there are few sites with clear trends as well. Two sites – Lazovski Zapovednik and the Iman – showed evidence of an increase and then decrease in wild boar numbers (peaking in 2003) while boar numbers in Ussuriski Zapovednik seem to have decreased across the entire monitoring period (Figure 16).

Table 12. Wild boar track densities (tracks/10 km) counted along survey routes within all 16 monitoring sites of the Amur Tiger Monitoring Program, 1998-2006

	Year										
Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Lazovski Zapovednik	1.51	2.52	5.49	5.08	8.04	7.82	11.18	5.96	2.57	6.17	5.63
Lazovski Raion	3.38	0.30	0.35	0.27	1.87	1.99	3.48	0.75	1.00	0.94	1.43
Ussurisk Zapovednik	13.60	29.56	4.24	25.63	5.33	0.99	4.13	7.79	8.90	3.27	10.34
Iman	4.17	1.55	0.22	0.66	2.51	1.14	5.32	3.97	1.68	1.03	2.23
Bikin	15.94	4.00	0.29	3.97	1.69	3.20	5.09	8.46	3.96	7.31	5.39
Borisovskoe Plateau	91.18	0.26	5.53	7.47	1.38	6.65	5.42	16.90	11.16	1.35	14.73
Sandagoy	0.42	2.76	2.68	0.54	1.04	2.42	5.40	1.83	1.74	0.66	1.95
Khor	1.17	0.66	0.37	2.27	1.71	2.13	1.68	6.34	2.93	4.57	2.38
Botchinski Zapovednik	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolshekhekhtsirki Zapov	1.36	3.16	0.61	3.36	2.29	26.43	4.57	2.14	4.46	2.07	5.04
Tigrini Dom	0.54	0.94	1.00	0.46	0.08	0.15	0.35	0.30	0.18	0.17	0.42
Mataiski Zakaznik	0.63	1.11	2.05	1.95	0.48	5.56	1.00	4.20	1.54	0.48	1.90
Ussuriski Raion	3.30	2.19	2.22	1.84	2.74	1.25	1.61	2.26	2.83	4.44	2.47
Sikhote Alin Zapovednik	4.47	4.21	2.69	3.64	1.91	1.91	2.61	11.31	5.63	1.62	4.00
Sineya	1.53	1.23	0.61	0.56	1.26	0.88	0.53	0.61	0.61	0.51	0.83
Terney Hunting Lease	4.76	0.75	1.22	0.20	0.18	0.72	1.37	1.57	1.75	0.38	1.29
Average	9.25	3.45	1.85	3.62	2.03	3.95	3.36	4.65	3.18	2.18	3.75

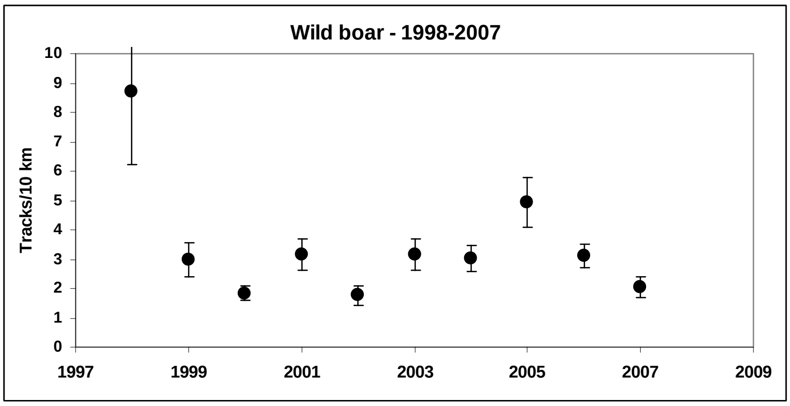


Figure 15. Average wild boar track density and 95% confidence intervals for all sites, for each of the nine years of the Amur Tiger Monitoring Program, 1998 though 2007.

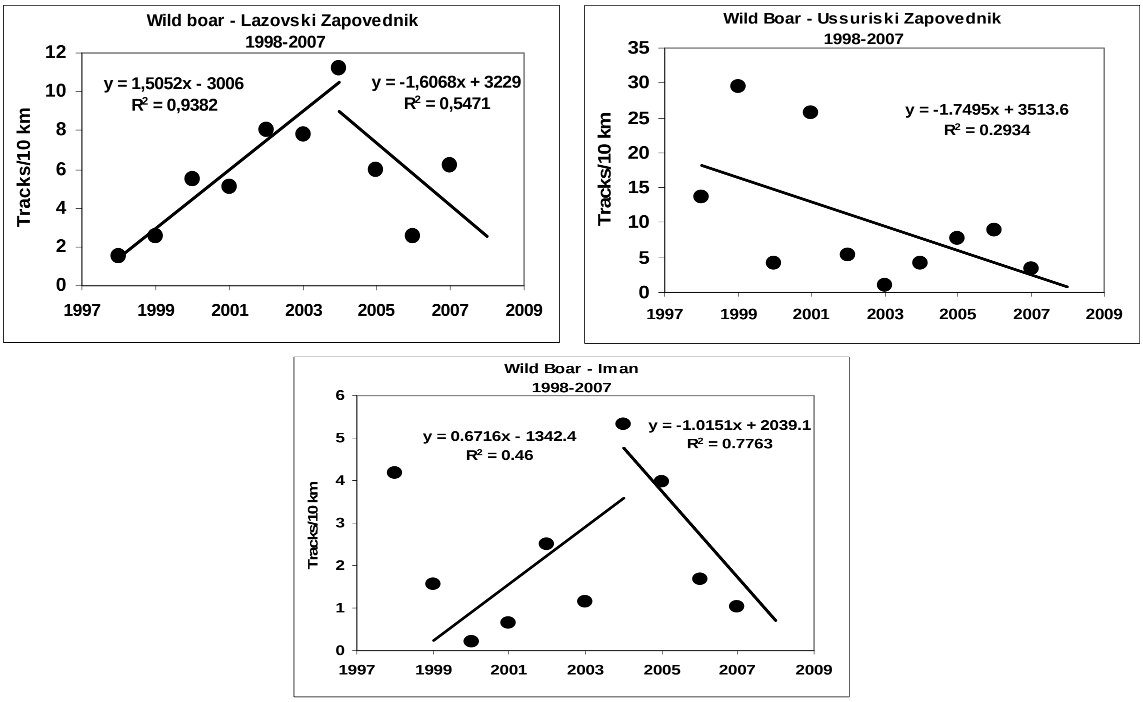


Figure 16. Changes in wild boar densities, as measured by fresh tracks/10 km along routes in 3 of the 16 monitoring sites of the Amur Tiger Monitoring Program. In contrast to red deer and roe deer, only a few sites suggesting declining numbers of wild boar over the entire monitoring period, or over the past 4-5 years.

Sika deer

Sika deer reach their highest densities in southern Primorski Krai, but also occur regularly in some of the central Amur tiger monitoring sites. Although there are reports of a few sika deer in Khabarovsk, they are mostly absent from this region (Table 10). Sika deer are found regularly in only eight of the monitoring units, including all 6 in the south, and 2 of the central monitoring sites (Table 10). However, in the two central units where they occur (Sikhote-Alin Zapovednik and Terney Hunting Lease) they exist in localized pockets, and are not uniformly distributed throughout the monitoring units. Sika deer appear to be increasing in the coastal areas of Terney Raion, and appear to be extending their range to the north, as more reports of sika deer are coming in from Khabarovsk and northern Terney Raion.

Track densities (and hence presumably animal densities) are generally much higher for sika deer than other ungulate species, reaching a peak of 183 tracks/10 km in Lazovski Zapovednik in 2005 (Table 13). Track densities average above 20/10 km on half of the 8 sites (Table 13). Highest track densities averaged across all years also occurs in Lazovski Zapovednik (Table 13).

Sika deer are highly gregarious, and there is great variation in track counts dependent on the number of groups encountered along transects. Greater sampling is probably required to obtain more accurate estimates of track densities, with smaller confidence intervals.

There are no trends that appear consistent across all 8 southern sites combined for the 10 years of monitoring, but there are important and opposite trends for some of the individual sites (Figure 18).

Table 13. Sika deer track densities (tracks/10 km) counted along survey routes within all 16 monitoring sites of the Amur Tiger Monitoring Program, 1998-2007.

Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Lazovski Zapovednik	47.44	43.85	106.99	123.38	92.50	42.71	83.71	183.81	120.40	67.87	91.27
Lazovski Raion	9.69	11.43	51.30	51.64	47.79	28.78	30.34	37.40	36.31	56.77	36.14
Ussurisk Zapovednik	21.22	16.12	31.17	27.61	24.66	11.97	22.67	18.04	19.88	14.80	20.81
Iman	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bikin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Borisovskoe Plateau	116.22	42.87	65.74	20.81	34.12	18.58	28.29	19.89	20.72	24.55	39.18
Sandagoy	0.84	2.46	4.06	7.91	4.27	2.86	1.26	1.27	1.35	1.75	2.80
Khor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Botchinski Zapovednik	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bolshekhekhtsirki Zapov	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tigrini Dom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mataiski Zakaznik	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Ussuriski Raion	0.57	0.34	2.74	2.01	1.21	1.07	0.64	1.29	2.54	1.00	1.34
Sikhote Alin Zapovednik	9.95	5.18	3.67	8.43	9.67	11.84	14.66	6.57	9.08	7.16	8.62
Sineya	0.16	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Terney Hunting Lease	6.56	1.61	2.00	0.53	1.28	3.37	1.43	0.51	1.44	0.08	1.88
Average (n=8)	26.56	15.48	33.46	30.29	26.94	15.15	22.87	33.60	26.46	21.75	25.26

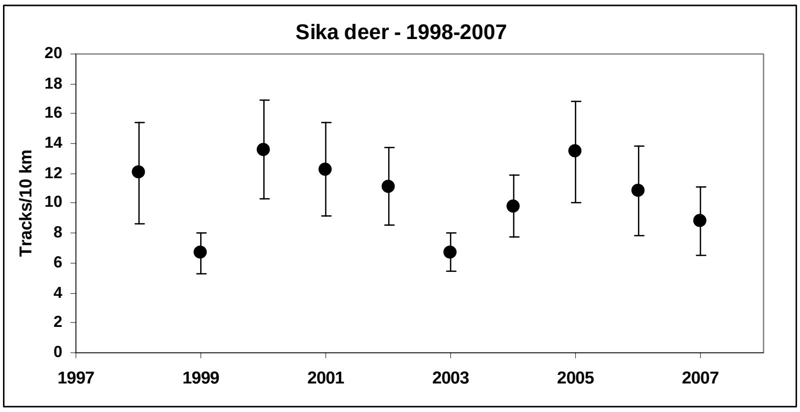


Figure 17. Average sika deer track density and 95% confidence intervals averaged across eight sites where they regularly occur, for ten years of the Amur Tiger Monitoring Program, 1998 though 2007.

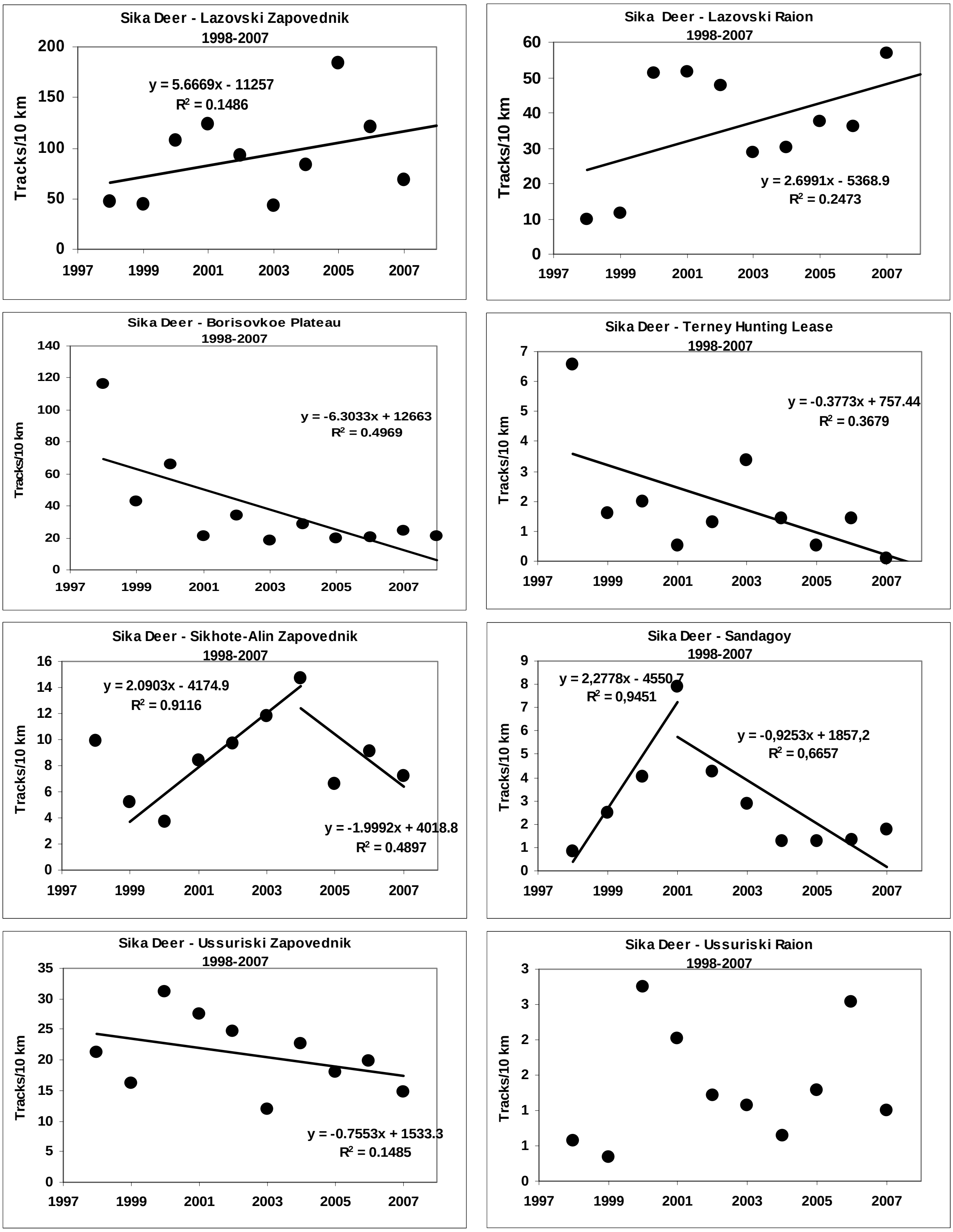


Figure 18. Changes in sika deer densities, as measured by tracks/10 km along routes in all 8 monitoring sites where this species occurs in the Amur Tiger Monitoring Program, 1998 through 2007.

Despite this apparent trend of range extension, the data across all 8 sites where sika deer normally occur does not suggest that, overall, sika deer numbers are increasing at those sites (Figure 17), but rather, suggests a relatively stable situation exists in general across the region. In the Lazovski area (Lazovski Zapovednik and Lazovski Raion) there are non-significant but nonetheless upward trends in population indices (Figure 18). Dramatic differences in the track counts between those adjacent units reflect the importance of protected areas in protecting even populations on the Russian Red Data Book – track densities in the zapovednik are 2-4 times higher than outside the protected area. Nonetheless, the general pattern in this region appears to be upward or stable.

Track count indices in Borisovskoe Plateau and Terney Hunting lease suggest sika deer numbers are decreasing in those units. This line of evidence reflects the low level of protection provided by the two hunting leases in which these units occur – Nezhinskoe Military Hunting lease and Terney Hunting lease.

Two other units – Sikhote-Alin Zapovednik and Sandagoy – have track indice patterns that suggest population numbers increased and then have decreased. The timing of the decline, however, varies. In Sandagoy, the beginning of the decline coincides with declines in red deer and roe deer across the region (2001-2002), while in Sikhote-Alin the population appears to have peaked in 2004.

Only in two of the eight count – Ussuriski Zapovednik and Raion – do track count indices show no clear trends.

Sika deer versus red deer. Right now the situation in Primorski Krai surrounding sika deer is quite controversial. Sika deer populations in Southeast Primorski Krai are protected as an endangered subspecies, but hunting is allowed on them elsewhere, for instance, in Southwest Primorye, in places such as Borisovkoe Plateau. Many people have noted that there is an inverse relationship between the abundance of red deer and sika deer, i.e., as sika deer numbers increase, through some mechanism (competition, or perhaps disease) red deer numbers decrease. Most of the information available to corroborate this trend is largely anecdotal. We use the data collected from four sites (Lazovski raion, Ussuriski Zapovednik Sikhote-Alin Zapovednik and Terney Hunting lease) where red deer numbers have decreased significantly over the nine years of the monitoring period, and where sika deer also occur, to determine whether there is a negative relationship between sika deer abundance and red deer abundance.

We used a curve-fitting program (CurveExpert 1.3) to derive the best fit of linear and nonlinear models. The result produced a Rational Function where y=(a+bx)/(1+cx+dx^2) and where the coefficient data was calculated as:

a = -0.26032243
b = 1.9926929
c = -0.19926879
d = 0.021215785

The resulting graph of the relationship of red deer and sika deer densities is quite interesting (Figure 19) in that it suggests that red deer and sika deer populations can both increase when densities of both are relatively low. However, there appears to be a critical density of sika deer (after 25 tracks/10 km) where red deer densities begin to decline quite dramatically, and by the time sika deer densities approach 50 tracks/10 km, red deer are nearly absent from such sites.

While this analysis is preliminary, it does suggest that there is a clear relationship between the abundance of sika deer, and the decline of red deer in a given area. The reason for such a decline is still open to debate, but the relationship appears to be relatively clear, in that red deer can thrive in areas where sika deer densities are relatively low, but once they reach a critical density, red deer seem to be eliminated from the area. Sika deer have the capacity to reach densities that have rarely been reported for red deer, and hence, as a source of food for tigers, assuming tigers have equal success in capture, the total biomass provided by sika deer will be considerably greater than that of red deer, even though the body mass of red deer is considerably greater than of sika deer.

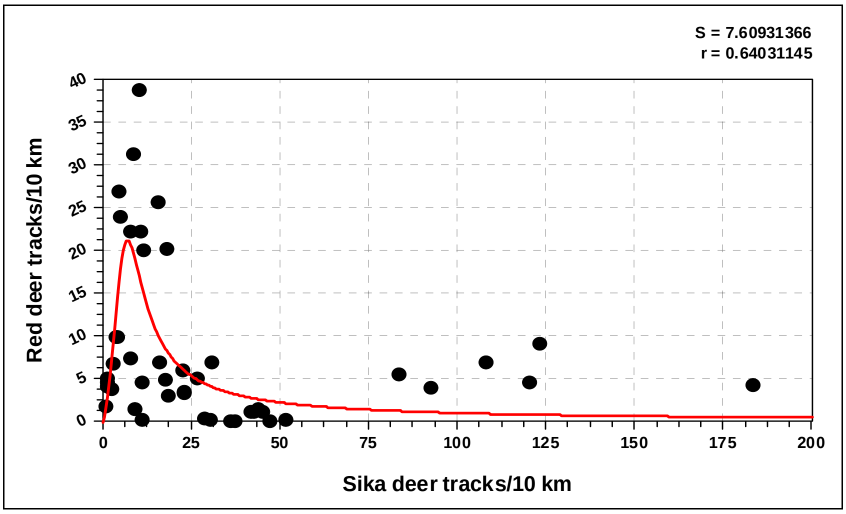


Figure 19. Track densities of red deer and sika deer, plotted for 4 sites where red deer numbers have decreased through the nine years of the Amur Tiger Monitoring Program, and where sika deer numbers are also present.

Roe deer

Roe deer are the only ungulate species that is found on all 16 monitoring sites. In the 2006-2007 winter the average roe deer track index was 2.81 $\pm$ 0.27 (SE) tracks/10 km of survey route (Table 14). This estimate is significantly less than the 10-year average (4.42 $\pm$ 0.41) (Table 14) and is much lower than any other year since monitoring began in 1998.

As with red deer, there is evidence that roe deer densities increased during the early years of the monitoring program, but have since started declining. While that decline apparently began in 2001 for red deer, the decline for roe deer appears to start a little later, in 2003 (Figure 20). Patterns within individual monitoring units generally support this overall picture. In only one unit (Bikin) does there exist any evidence that numbers might be increasing (Figure 21). In three units there is a general decline in roe deer track densities over the entire monitoring period (Lazovski Zapovednik, Lazo Raion, and Ussuriski Zapovednik). In the Matai Zakaznik there is a downward trend with the exceptional year of 2003. In five other units there is evidence of an increase in roe deer numbers through 2001-2003, following by a decline through 2007.

Table 14. Roe deer track densities (tracks/10 km) counted along survey routes within all 16 monitoring sites of the Amur Tiger Monitoring Program, 1998-2007.

	Year										
Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Lazovski Zapovednik	4.49	2.40	4.35	2.73	4.07	0.62	0.97	2.47	1.29	0.67	2.41
Lazovski Raion	4.18	1.01	1.04	0.11	1.40	0.10	0.97	0.35	0.41	0.09	0.97
Ussurisk Zapovednik	13.08	8.61	10.53	6.62	6.31	2.19	1.60	2.03	2.44	1.81	5.52
Iman	3.83	2.68	3.16	4.45	4.29	5.50	3.50	5.04	4.18	3.46	4.01
Bikin	1.61	4.96	1.39	2.88	4.49	3.41	4.73	5.43	3.95	5.35	3.82
Borisovskoe Plateau	3.38	8.48	4.58	6.22	11.27	2.69	4.36	3.78	2.26	5.00	5.20
Sandagoy	2.37	2.44	6.70	8.98	11.94	6.39	3.26	3.94	4.39	2.55	5.30
Khor	2.42	7.60	2.73	2.85	5.25	4.05	5.62	6.45	5.48	1.80	4.43
Botchinski Zapovednik	0.43	2.99	2.69	4.59	3.91	6.55	7.51	2.44	1.82	0.60	3.35
Bolshekhekhtsirki Zapov	0.64	1.27	0.16	1.36	4.86	0.64	4.36	1.57	3.34	4.86	2.31
Tigrini Dom	0.65	1.04	0.36	0.28	0.59	0.08	0.45	0.15	1.88	0.13	0.56
Mataiski Zakaznik	1.46	2.62	2.10	1.49	1.39	4.02	1.46	1.45	1.27	1.03	1.83
Ussuriski Raion	7.79	7.92	11.73	7.93	4.68	2.03	2.55	2.58	4.53	4.84	5.66
Sikhote Alin Zapovednik	16.24	11.50	17.53	16.94	13.69	19.17	21.45	15.64	22.50	7.06	16.17
Sineya	2.39	2.59	2.37	3.77	3.01	5.55	2.12	4.27	1.73	1.04	2.88
Terney Hunting Lease	6.61	4.58	4.67	8.33	4.63	10.87	7.25	6.02	7.48	2.95	6.34
Grand Total	4.47	4.54	4.76	4.97	5.36	4.61	4.51	3.98	4.31	2.70	4.42

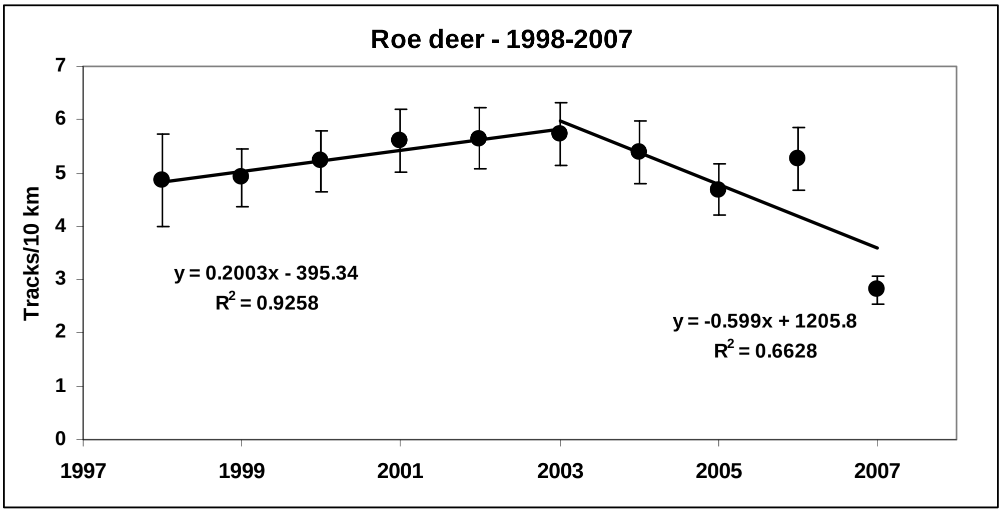
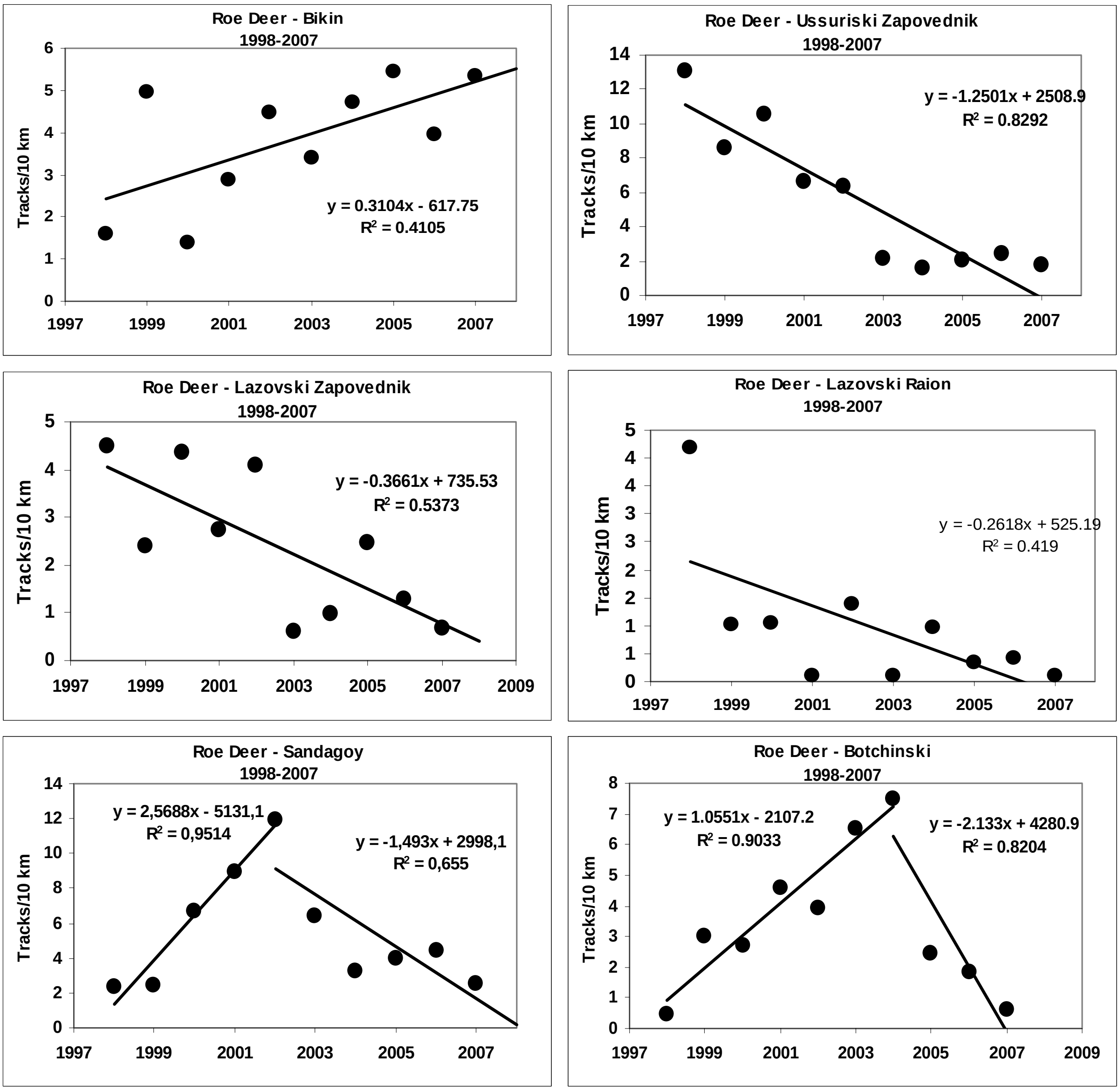


Figure 20. Average roe deer track density averaged across for all study sites, for 10 years of the Amur Tiger Monitoring Program, 1998 though 2007.



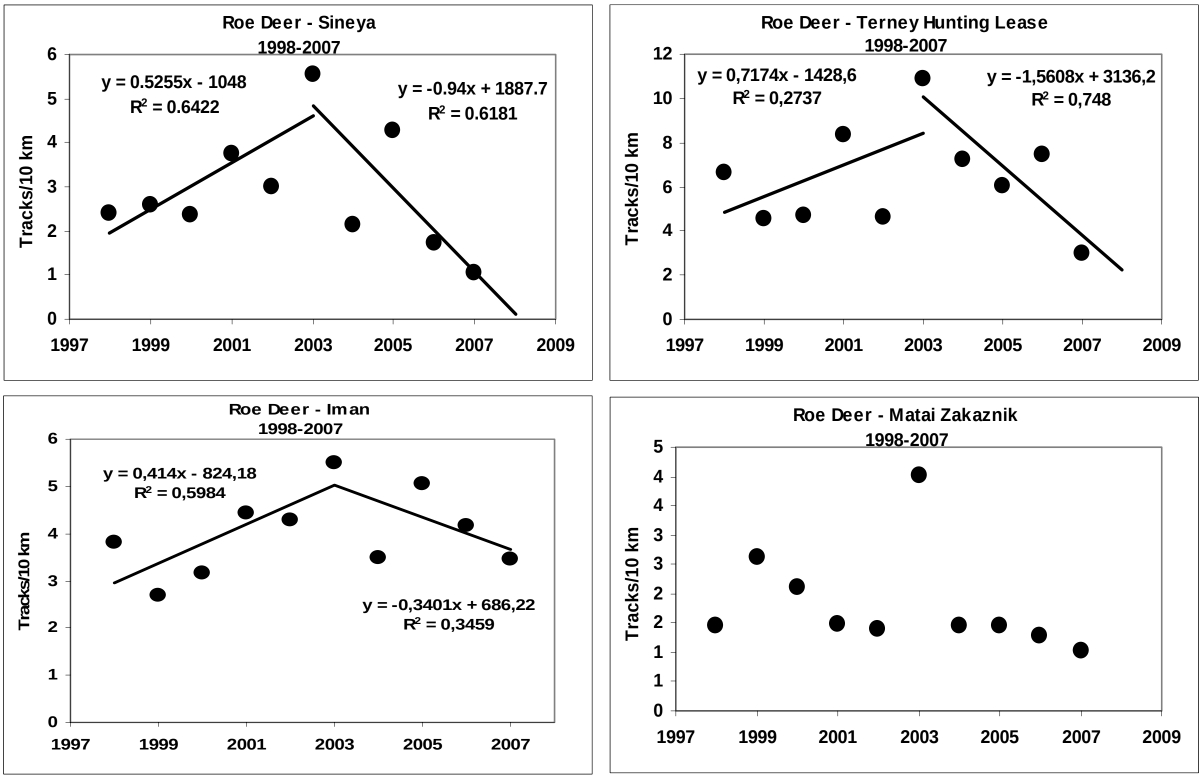


Figure 21. Changes in roe deer densities, as measured by tracks/10 km along routes in ten monitoring sites in the Amur Tiger Monitoring Program, 1998 through 2007.

Roe deer versus sika deer. Whether decreases in roe deer numbers in the south are also related to increases in sika deer numbers, as appears to be the case with red deer, has not been investigated at all. We plotted track density of sika deer versus roe deer for the 4 monitoring units where the two species co-occur, and used the same approach as with red deer to derive the best fit of linear and nonlinear models. The resulting model is very similar to that derived between red deer and sika deer (Figure 22). Employing a rational function of the form y=(a+bx)/(1+cx+dx^2), the coefficient variables derived are:

a = 3.6323795
b = 1.0405012
c = -0.09497496
d = 0.010798039

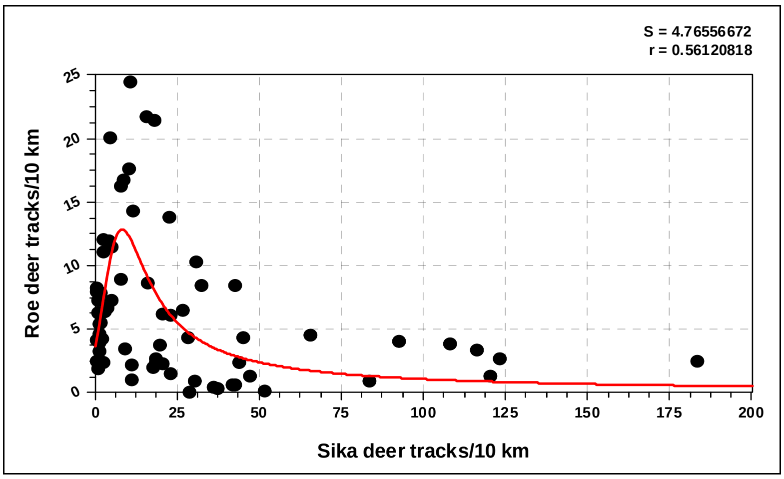


Figure 22. Track densities of roe deer and sika deer, plotted for 4 sites where roe deer numbers have decreased through the nine years of the Amur Tiger Monitoring Program, and where sika deer numbers are also present.

As with red deer, this model suggests that at low densities sika deer do not seem to have an impact on roe deer densities, and in fact, both can increase simultaneously. However, once sika deer densities reach some critical level (about 50 tracks/10 km, slightly greater than for red deer), then roe deer densities begin to drop quite dramatically, and while the do not seem to disappear from a system, levels remain below 5 tracks/ 10 km. The mechanisms responsible for these relationships are still speculative, but it appears that sika deer are capable of reaching extremely high densities, to such an extent that they are pushing other tiger prey species either completely out of systems, or in marginal existences. Clearly the relationships of these ungulates is an interesting and pertinent point in terms of how changes in population dynamics of specific prey species can impact the entire prey complex. How these changes affect tiger densities is still open to question. Assuming equal capture probability, higher prey biomass should be a good thing for tigers. This issue is certainly worthy of further examination.

Status of Amur Tigers in the Russian Far East

We use three indicators to assess changes in the status of the Amur tiger population in the Russian Far East over the past ten years: occupancy, track density, and expert estimates of tiger density. Because any single measurement has its inherent biases and errors associated with it, we believe that using a weighting system that compares these three estimators will give a more balanced assessment of the status of tigers at any given point of time and in any given monitoring unit. Our monitoring program is designed not to provide an assessment of the absolute numbers of tigers in either Primorski or Khabarovski Krai, but to provide an assessment of changes in numbers. We believe that such a monitoring system, if sufficiently accurate, should act as an “early warning signal” which will allow the appropriate governmental agencies to react with this information. Thus, based on an assessment of the trends identified above, we believe there are a number of important conclusions that can be drawn.

In addition to the above three indicators, this year we have added indicators of cub production, and status of four key prey species (red deer, wild boar, sika deer, and roe deer). Cub production is difficult to use as an indicator, as, where there are relatively few adult females on a site, estimates of cub production will fluctuate greatly from year to year depending on whether females have new cubs, or have just lost cubs to dispersal. Therefore, we have tried to account for the natural high variability by comparing the average of the previous three years to the 10 year average. Where the difference between these two averages is greater or less than 20% of the 10-year average, we consider it notable as an indicator. We have also included indicators (+ or -) of the four key ungulate species if there is evidence of a significant trend (P=0.2) over some measurable period. Because trends are likely to change within the 10-year period on any given site, we have looked for evidence for any consistent trends across any period of 4 or more years.

If any indicators are positive or negative, we simply record them as a +1 or -1 in Table 15, and sum the scores to provide an assessment of the relative conditions for tigers at each site. Because not all sites have all four prey species, this approach results in some imbalance in the total sum score, so the total sum of plus and minus values is divided by the total number of parameters for each site, giving a value between -1 and +1, with the values closer to +1 representing positive changes, and the values closer to -1 representing negative changes. We believe this scoring system acts as a relatively useful index of the situation for tigers at each of the monitoring sites.

Using these indicators, the Iman monitoring unit appears to be the area where the situation has deteriorated most significantly in recent years. All three indicators of tiger abundance suggest a decline, and there are declines in all three key prey species. This area clearly should be a priority for focusing better law enforcement and control of hunting.

Surprisingly, Ussuriski Zapovednik also comes out as an area of concern. While tiger numbers still remain relatively high, indicators suggest it is decreasing, and while cub production is also high, it has also decreased slightly (but less than 20%) in comparison to previous years. Evidence of declines of wild boar and roe deer suggest that prey availability may be declining there. In close proximity to both Ussurisk, Artyom, and Vladivostok, Ussuriski Zapovednik suffers human pressures on 3 of its 4 sides, and should act as an important barometer of human influences on the tiger population. Hence, declines in Ussuriski Zapovednik may be taken as a potential indicator of increasing human pressures. While the status of Ussuriski Raion does not appear as problematic, the difference may simply represent that low densities of tigers and prey already exist in this region. Overall, these results indicate a need to improve law enforcement in and around the Ussuriski Zapovednik.

Bolshekhekhtsirski Zapovednik represents an isolated island of habitat, and it is perhaps to be expected that tiger numbers and densities will vary dramatically here. A loss or addition of a single individual greatly changes the estimate of density, and because it is isolated, this population can be expected to be ephemeral, changing in density often, and occasionally blinking out completely. Presently there appears to be a single tiger in the zapovednik which suggests this island of habitat may soon become devoid of tigers. However, as long as corridors are retained with the greater Sikhote-Alin system, recolonization will still be highly likely, as this is a high quality, though small patch of tiger habitat. Red deer, the primary prey for tigers in the northern two-thirds of their range, are abundant here, and along with the fact that the reserve is relatively well protected, this area represents high quality habitat.

In recent years Sikhote-Alin Zapovednik and the neighboring Terney Hunting lease were areas of high concern due to decreasing estimates of tiger track density, occupancy, red deer numbers, and roe deer numbers. The situation within the Zapovednik seems to have improved, at least partly due to an increase in cub production. Nonetheless, Terney Hunting Lease is still problematic, with decreasing indices of tigers, red deer, and roe deer. Current efforts to control illegal hunting in this region appear insufficient to counter the growing pressures of local inhabitants.

For the first time in the 10 years of this monitoring program, the situation for tigers appears to be declining. Of the 117 indicators across Table 15, 38% suggest negative trends, versus only 7% that indicate positive trends. While the majority of indicators (55%) suggest no positive or negative changes, overall the indications are that conditions are declining for tigers. In some places, this is noted by a decrease in key prey species, in a few places by declining cub productivity, and in some by indications that the number of tigers may be declining.

There is mounting evidence that red deer and roe deer numbers are declining generally across the Russian Far East, although it is more pronounced in some areas. For both species, it appeared that numbers were stable or slightly increasing across all sites through 2001 or 2002, and then started a decline through 2007. While there are not major trends for either wild boar or sika deer, there are few places where positive trends exist.

If conditions are deteriorating for tigers (in terms of decreasing prey), it is likely that reproduction will be affected prior to a decrease in tiger numbers. This is because of prey numbers are low, tigresses will be hard-pressed to provide adequate food for their young, and we would therefore predict lower survival of cubs. Indeed, the number of cubs reported on monitoring sites appears to be decreasing since 2001. Four sites reported cub density averaged over the past three years to be higher than the 10-year average by 20% or more, while 10 sites reported cub density 20% or more lower than the 10-year average for that site

The most “stable” indicator in Table 15 appears to be the expert assessments. Whether or not these assessments are sensitive enough to detect changes is an important topic that will be investigated further. For now, we suggest that other indicators, including presence/absence of tigers on routes and track density indicators of tigers, suggest that, across a large number of monitoring units, tiger numbers may be decreasing.

Low prey numbers and depressed reproduction are clear signs that changes are occurring across tiger habitat. A number of changes in management are necessary to rectify this situation; most importantly, law enforcement efforts must be improved. Changes in government structures and responsibilities has greatly reduced the effectiveness of law enforcement, and the capacity of field inspectors to prosecute offenders. We hope that as the new governmental structures responsible for managing hunting, and controlling poaching develop, this situation will be seen as a temporary problem. However, it is worth noting that changes clearly seem to be declining, and this decline should be noted by the appropriate authorities.

Table 15. Status of conditions on the 16 monitoring sites of the Amur Tiger Monitoring Program for tigers are compared using 8 indicators: three estimators of tiger abundance (presence/absence trend, track density trend, adult tiger numbers trend); changes in cub producitivity over the past three years greater or less than 20% of the 10-year average; significant negative or positive trends in red deer, wild boar, sika deer and roe deer numbers (P = 0.2) . Sites are ranked from areas of greatest concern (where all three indicators suggest tigers are decreasing) to areas of least concern (where all three indicators suggest tiger numbers are increasing. "Scorecard" is based on data from 10 winters (1998 through 2007). Ratings represent the extent of agreement in estimators, and the direction in trend (decreasing/increasing) of the indicators.

		Tiger abundance										
#	Monitoring unit	% tiger presence on rtes	Tiger track density	Tiger density	Cub Production	Red deer trend	Wild Boar trend	Sika deer trend	Roe deer	# parameters	Rating	Scale of Concern
4	Iman	-	-	-	0	-	-		-	7	-0.85714	
3	Ussuriski Zapovednik	-	-	0	0	0	-	0	-	8	-0.5	
6	Borisovkoe Plateau	0	0	0	-		-	-	0	7	-0.42857	
7	Sandagoy (Olginski Raion)	0	0	0	-	-	0		-	7	-0.42857	
8	Khor	-	0	0	-	-	0		0	7	-0.42857	
10	Bolshe Khekhtsirski Zapovednik	-	-	0	-	+	0		0	7	-0.42857	
16	Terney Hunting lease	-	-	0	+	-	0		-	7	-0.42857	
2	Lazovski Raion	0	0	0	-	-	0	0	-	8	-0.375	
11	Tigrini Dom	0	0	0	-	-	0		0	7	-0.28571	
14	Sikhote-Alin Zapovednik	0	-	0	+	-	0	-	0	7	-0.28571	
5	Bikin River	0	-	0	0	-	0		+	7	-0.14286	
1	Lazovski Zapovednik	0	0	+	0	0	-	0	-	8	-0.125	
9	Botchinski Zapovednik	0	0	0	-	+	0		-	7	0	
12	Matai Zakaznik	0	0	+	0	-	0		0	7	0	
13	Ussuriski Raion	0	-	0	+	0	+	0	0	8	0.125	
15	Sineya (Chuguevski Raion)	0	0	0	-	-	0		-	7	0.42857	

WCS is a non-governmental, science-based conservation organization. Founded in 1896 as the New York Zoological Society its mission is to conserve wildlife and ecosystems by generating and applying innovative scientific and field-based solutions to critical problems.