A MONITORING PROGRAM FOR THE AMUR TIGER

SIXTH-YEAR REPORT: 2002-2003

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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Executive Summary

Standardized survey techniques, agreed upon all collaborating biologists and scientific institutions, have been used since the 1997-1998 winter season to monitor the status of Amur tigers in the Russian Far East. In the 2002-2003 winter 16 monitoring units, totaling 23,555 km^2 (approximately 15-18% of suitable tiger habitat) were surveyed to assess changes in tiger numbers using relative and absolute indicators of tiger abundance, cub production, mortality, and relative ungulate densities. 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).

Last year was the first time all three indicators of tiger abundance suggested that tiger numbers may be declining. This year, two of these indicators, track presence on survey routes, and expert assessments of tiger abundance, increased slightly, suggesting that a downward trend may have halted, or been a statistical and not biological phenomenon. However, the trend analysis using track abundance data for the past 5 years continued to demonstrate a significant decline (Figure 4: r^2 = 0.81, P = 0.037), suggesting that a decrease in tiger numbers may in fact be real. Other indicators (presence of tiger tracks on routes and expert assessments of tiger numbers) are not statistically significant.

Cub production continues to be an area of concern. Although the total number of cubs produced this year on all sites combined (23) is very close to the 6-year average (23.8), the number of litters being produced continues to decline (Figure 10). Total cub production remains stable because litter size appears to be increasing. The reason for this increase in litter size is not clear, but the results indicate that fewer and fewer monitoring sites are producing cubs; 61% of the cubs reported over the 6 years of monitoring have been produced on 5 sites (31% of sites), and there is a trend towards fewer and fewer sites producing cubs (Figure 11). Further increases in litter size are unlikely, and therefore continued decline in cub production on many sites

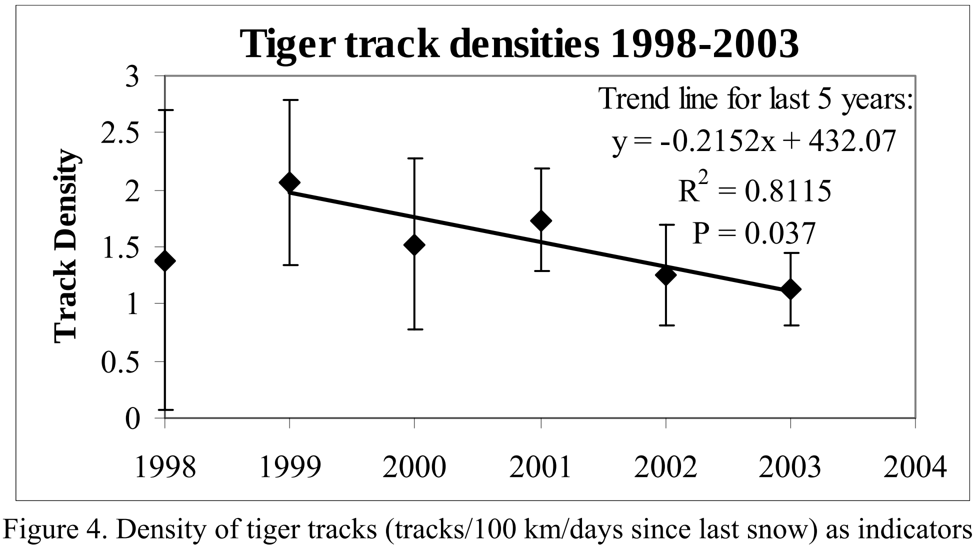

Figure 4. Density of tiger tracks (tracks/100 km/days since last snow) as indicators of tiger abundance averaged across 16 sites included in the Amur Tiger Monitoring Program; trend line estimated for past 5 years.

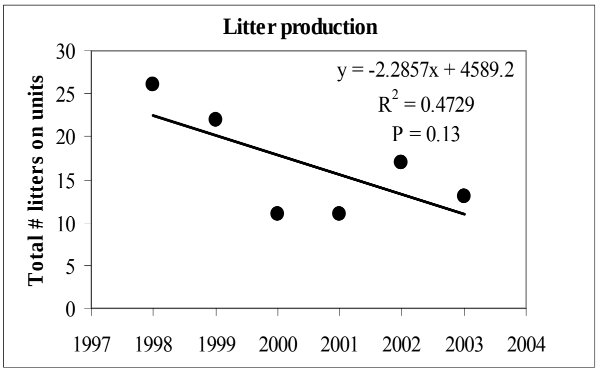

Figure 10. Litter production (total number of litters produced) on all 16 units combined for the Amur Tiger Monitoring Program appears to be decreasing. Figure

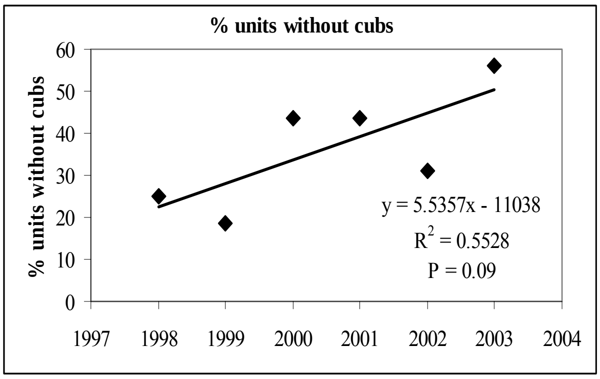

Figure 11. Percent of sites without cubs appears to be increasing over time in the Amur Tiger Monitoring Program, based on 6 years of monitoring, winter 1997-1998 through 2002-2003.

suggests that recruitment in the future may not be able to compensate for total mortality, in which case we would anticipate a further decline in tiger numbers.

Development of a scorecard that provides a weighted assessment of tiger abundance indices, prey abundance indices, and tiger reproduction allows us to assess overall trends at individual monitoring sites. Five monitoring sites appear to be areas of concern.

Sikhote-Alin Zapovednik and neighboring Terney Hunting Lease both have strong indications that tiger numbers are decreasing as well as wild boar and red deer (Sikhote-Alin only for red deer). The cause for this decline is unclear. Based on radio collared tigers in and around Sikhote-Alin, we do not have evidence that poaching on tigers per se has increased. Investigations should begin to insure that other human-related variables are not responsible for the decrease.

Ussuriski Zapovednik and neighboring Ussuriski Raion also are areas of concern. Two of three indicators suggest that tiger numbers may be decreasing in the Zapovednik, and sika deer and roe deer appear to be decreasing in both sites. Ussuriski Zapovednik traditionally has one of the highest tiger densities reported anywhere in the Russian Far East, but it is also one of the closest sites to major centers of human development (with the cities of Ussurisk and Vladivostok within easy driving distance). Therefore changes in the status of tigers and their prey here are of great concern. We recommend that zapovednik staff review their own prey and predator monitoring data to assess the present status of tigers and prey, to identify causes of declines and hopefully initiate intervention activities to reverse these trends.

Despite a pattern of decreasing reproductive activity in Khabarovsk the only site in Khabarovsk that appears to be an area of concern is Bolshe-Khekhtsirski Zapovednik. This small island of habitat, although harboring high (and apparently increasing) numbers of red deer and wild boar, is simply too small, and too close to the city of Khabarovsk, to maintain a stable tiger population. This island of habitat is likely to experience frequent localized extinctions and recolonization, as long as some form of connectivity can be maintained with the main Sikhote-Alin population. In fact, improving stability of this population may be dependent more on securing a corridor to the Sikhote-Alin than any internal management or manipulations of the zapovednik per se.

Overall, results provide an indicator that tiger numbers are definitely not increasing across their range of tigers, and there are signs of notable reductions in tiger numbers, especially in Primorski Krai, with a reduction in reproductive output from Khabarovski Krai. The available information should act as an early warning signal that the status of the Amur tiger may be worsening.

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.

5. Finally, changes in habitat conditions can also provide an indicator as to the present and future status of Amur tigers in the wild. Understanding the relationship of human impacts on habitat and tiger numbers is a difficult undertaking, but one way to gain better insight is to monitor specific sites over time to compare changes in human impacts with changes in 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. Below we detail the methodology in use, provide justifications for its use, and indicate how the data can be employed to monitor trends in tiger numbers, and indicators of the status of the Amur tiger population in Russia.

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.

6. Record and monitor instances of tiger mortality within and in close proximity to count units.

7. Monitor changes in habitat quality.

III. METHODOLOGY

We emphasize that any survey design has limitations, and it is therefore the responsibility of program authors to clearly define their goals and objectives, and the methodology used to obtain those goals and achieve those objectives.

We believe that the following questions should be addressed in designing a monitoring program for Amur tigers:

1. What should be measured as an index of tiger abundance, and is the index a valid indication of true tiger abundance?

2. Where should the monitoring program be conducted, and how many count units are needed?

3. How should data be collected within monitoring sites?

4. When, and how often, should monitoring be conducted?

5. What should be measured as an index of tiger productivity?

6. What should be measured as an index of prey abundance?

7. How should mortality be monitored?

8. How should habitat changes be monitored?

9. How should data be stored?

10 How should data be analyzed?

11. Does the design of the monitoring program permit a reasonable statistical probability of detecting trends that may occur in the population index?

Below, we address each of these questions in the design of our monitoring program.

1. What should be measured as an index of tiger abundance, and is the index a valid indication of true tiger abundance?

All tiger surveys conducted in Russia since the 1940's have either relied on interview data of hunters and forest guards (Kudzin 1966, Kucherenko, 1977, Kazarinov 1979) or have relied on track information collected in winter (specifically track numbers, distribution, size, and age) to develop an "expert assessment" of tiger numbers (Kaplanov 1947, Abramov 1962, Yudakov and Nikolaev 1970, Pikunov et al. 1983, and Pikunov 1990. Of these two approaches, it is clear that expert assessments provide a more precise estimate of tiger numbers, but even this approach has its drawbacks: different experts interpret data in different ways, providing the possibility for the same data set to be interpreted in different ways (e.g., compare Pikunov 1985 and Bragin and Gaponov 199X, Kucherenko 2001).

Because reliance on a single methodology may lead to mistakes or misinterpretation of data, we developed a methodology that relies on three indicators of tiger abundance: 1) presence/absence of tiger tracks on routes; 2) track density on routes; 3) expert assessments of number of tigers in each count unit. These three indicators use different types of data to derive indicators of tiger abundance. Because they are at least partially independent, they provide distinct and separate indicators of trends in tiger numbers.

1. Presence/absence of tiger tracks on survey routes.

Presence/absence of tiger tracks on survey routes (expressed as the percentage of routes on each monitoring unit with no tiger tracks recorded) should provide an indication of relative abundance of tigers. We record zero counts on routes when tracks were not reported on routes in either the early or later winter survey (as noted below, each survey route is sampled twice per winter season). Monitoring units can then be ranked on the basis of percentage routes with (without) tiger tracks as an indicator of relative abundance, which can also be compared among years within each unit.

2. Tiger track densities.

An index of tiger abundance, based on track counts measured on sampling units well dispersed across the total range of tigers, should provide an index of relative abundance of tiger numbers that can be used to monitor trends. Changes in count estimates over time within each count unit should provide an indication of changes across the entire range. Furthermore, by distributing count units across the entire range of conditions that tigers exist in the Russian Far East, it may be possible to detect changes that may be regional or localized.

Tiger track densities are expressed as a function of number of tracks recorded along each survey route adjusted by the length of the survey route, and the time since last snow (the greater the interval since the last snow, the more time for tiger tracks to accumulate). The number of tracks is first divided by the length of each route for each survey (2 conducted per winter), providing an estimate of tracks/km for each survey separately. Tracks/km is then divided by the number of days since the last snowfall, providing an estimate of tracks/day/km, which is arbitrarily multiplied by 100 to provide an estimate of tracks/day/100 km. The mean derived from this value for both surveys in each winter is taken as the track density estimator for each separate route.

There are two problems using days since last snow to adjust the track density estimator. First, in some cases, the date of last snow is unknown, or not reported. Secondly, degradation/elimination of tracks can occur between snowfalls when the interval is large, resulting in an underestimation of track densities. Based on a preliminary assessment in Sikhote-Alin Zapovednik, nearly all tracks become immeasurable after 7-8 days. However, many of these can still be identified as tiger tracks. By approximately 14 days, however, most tiger tracks are fairly well obliterated.

Based on these considerations, we used the following standards for adjusting the track density estimator for days since last snowfall:

1. number of days since last snow, when the last snowfall was less than or equal to 14 days;
2. 14 days, if the last snow was greater than 14 days ago (assuming that tiger tracks will deteriorate beyond recognition by that time);
3. 14 days, if either date of last snow or date route was traveled is unreported.

***3. Expert assessment of tiger numbers*.**

Coordinators for each site develop an estimate of the number of tigers present on each monitoring site during the winter period (December-February). Their source of data for these expert assessments are threefold: 1) track data from the survey routes; 2) additional records of tracks on monitoring sites that are not recorded on survey routes during the 2-stage survey (see below); 3) interview information that is collected from local informants. Based on these sources, by comparing track sizes, distances of tracks from each other, dates tracks were created, and the coordinator's understanding of tiger social structure and behavior in relationship to the local physical environment, each coordinator derives an estimate of the likely number of tigers on the study site, and provides an estimate of age (adult, sub-adult, cub, unknown) and sex (male, female, unknown). If evidence of a particular tiger is recorded in only one of the survey periods (i.e., it may have been a transient, may have died, or was simply missed in one of the counts), that animal is nonetheless included in the total count for the study period as a measure of the "total number of tigers that were present at some time on the monitoring site during the monitoring period." While the way in which different experts interpret track data undoubtedly varies, these expert assessments, conducted by the same coordinators on the same sites over extended periods of time, provide a valuable indicator of changes in tiger numbers on that site.

For analyses, we combined all age classes except cubs (adults, sub-adults, and unknown) to form an estimate of number of "independent tigers" (i.e., independent of their mother) existing on a monitoring site during the survey periods. The number of independent tigers was used to estimate tiger density, which provides a basis for comparisons among sites. As with presence/absence and track density estimates, we conducted a trend analysis for all sites combined, and each site separately using track density data.

Variations in all three indicators of tiger abundance can be measured across at least 3 types of parameters:

i. overall trends in tiger numbers (by measuring changes across all count units);

ii. regional variation (assuming the population may be changing differently among regions, by looking for differences in:

-northern, middle, and southern monitoring sites;

-coastal versus inland monitoring sites;

-protected versus unprotected monitoring sites;

iii. variation among sites is likely due to a number of factors, and an assessment of the impacts and conditions within each site may reveal reasons for this variation.

2. Where should the monitoring program be conducted, how many count units are needed, and what size should they be?

Sampling only a portion of the entire distribution of tigers provides a more efficient and cost-effective means of monitoring tigers than an entire count. However, location of sampling units should be well dispersed across the total range of tigers. Changes in count estimates over time within each count unit should provide an indication of changes across the entire range. Furthermore, by creating several count units represented in each key geographic region across the entire range of conditions that tigers exist in the Russian Far East, it may be possible to detect changes that may be regional or localized.

We have attempted to define a set of count units based on criteria outlined below, and then develop a sampling scheme within each count unit that will provide an estimate of relative tiger abundance based on track abundance, as well as derive estimates of relative tiger abundance based on the three indicators described above. The sampling scheme was primarily designed to reduce variance in tiger track counts within each monitoring unit (which act as a sampling units), but the efficiency of sampling prey species was also considered. Below we define what criteria were used to select count units.

Location of count units.

The set of count units selected should be dispersed across tiger range to represent the full range of conditions in which tigers occur. Both high quality and marginal areas should be monitored. It is also important that protected areas be monitoring using the same methodology as in unprotected areas to provide a comparison of the impacts of human activities on tiger populations. We also sought to create "parallel" monitoring units within and adjacent to the larger zapovedniks (Sikhote-Alin, Lazovski, and Ussuriski) to act as paired comparisons of protected and unprotected area that share nearly all features except protected status. Unprotected count units adjacent to protected areas should theoretically demonstrate higher densities of tigers and prey than most unprotected areas because they lay immediately adjacent to source populations, but not so high as the zapovedniks themselves. These paired comparisons may be sensitive indicators of the effect of human impacts.

We determined that the following parameters may be important determinants of tiger abundance:

Protected status: protected (as zapovednik)/unprotected areas;

Latitude: northern, central, or southern; and,

Geographic location: inland or coastal.

We defined protected areas only as those areas with zapovednik status. Although some sites have partially or wholly protected as zakazniks (Borisovkoe Plateau, Matai), these designations are either relatively new, or do not provide the same level of protection afforded to zapovedniks. It is commonly assumed that latitude is an important factor affecting tiger density, and that density decreases at the northern limits of its range. Therefore sites in Khabarovski Krai should theoretically retain lower tiger densities than sites to the south. We assigned all count units to one of three latitudinal sections: *northern*, which includes all of Khabarovski Krai; *central*, which includes the northern half of Primorski Krai; and, *southern*, which includes the southern half of Primorski Krai. Finally, there are important and habitat differences between *coastal* areas (i.e., those drainages that flow into the Sea of Japan) and *inland* sites (all drainages that flow into the Ussuri and/or the Amur River). Because forest types and weather varies between coastal and inland sites, it is possible that ungulate densities, and ultimately tiger densities, also vary. In all cases except for Borisovkoe Plateau, this designation represents the west and east sides of the Sikhote-Alin Mountains, respectively.

Number of count units.

The number and location of count units should be determined by a number of factors: 1) there should be adequate representation of the environmental variables as defined above; and 2) the sample size should be sufficient to allow statistical analyses for overall trends in population and differences due to environmental variables (e.g., protected/unprotected); 3) there should be personnel and an infrastructure that will insure long-term monitoring will be consistently carried out on all designated sites; 4) financial constraints will largely limit the number of sites that can be consistently funded.

Size of count units.

Our criteria for determining size of count units were as follows:

i) potential for variability in tiger numbers. To detect changes in tiger density, a count unit must be sufficiently large to potentially contain tiger numbers that could fluctuate over time, hopefully reflecting the conditions for tigers in the representative region. In other words, count units should be large enough to have a low probability of tigers being completely absent from the area during the survey period (if tigers are perennially absent from a count area, it is impossible to detect changes in population density), and large enough so that several or more tigers might be present. Hence, ideally a monitoring unit would contain an area large enough for 2-3 female territories.

ii) minimum size to provide variability but keep expenses low. Given that units must be large enough to contain several potential female home ranges; count units should be as small as possible to minimize the expenses of monitoring.

iv) natural or predefined boundaries. Count units should have natural boundaries reflecting geographic constraints on tiger movements (e.g., high ridgetops, large rivers) or predefined boundaries (e.g., protected areas boundaries, county or krai boundaries).

In good tiger habitat, assuming that female home ranges average 400-500 km^2 (Miquelle et al. 1999) 100,000 - 150,000 ha may contain 2-3 adult resident females, at least 1 adult male, transients, dispersers, and cubs. Therefore, we sought to create count units of approximately this size. Some exceptions were inevitable. For instance, the size of existing protected areas is obviously fixed (although with larger protected areas we sought to sample only a portion of the region). In general, we sought to keep count units with the range of 1000 - 1500 km^2.

Given these constraints, 16 permanent monitoring units have been created to be representative of the range of conditions across the present distribution of tigers (Figure 1, Table 1).

Table 1. Monitoring sites selected for the Amur tiger monitoring program in the Russian Far East.

#	Name	Size of unit (km^2)	Krai	Status	Latitude	Geographic location
1	Lazovski Zapovednik	1192.1	Primorye	Zapovednik	southern	coastal
2	Lazovski Raion	987.5	Primorye	unprotected	southern	coastal
3	Ussuriski Zapovednik	408.7	Primorye	Zapovednik	southern	inland
13	Ussuriski Raion	1414.3	Primorye	unprotected	southern	inland
6	Borisovkoe Plateau	1472.9	Primorye	Zakaznik (partially)	southern	coastal
7	Sandagoy (Olginski Raion)	975.8	Primorye	unprotected	southern	coastal
4	Vaksee (Iman)	1394.3	Primorye	unprotected	central	inland
5	Bikin River	1027.1	Primorye	unprotected	central	inland
14	Sikhote-Alin Zapovednik	2372.9	Primorye	Zapovednik	central	coastal
15	Sineya (Chuguevski Raion)	1165.4	Primorye	unprotected	central	inland
16	Terney Hunting lease	1716.5	Primorye	unprotected	central	coastal
8	Khor	1343.8	Khabarovsk	unprotected	northern	inland
9	Botchinski Zapovednik	3051	Khabarovsk	Zapovednik	northern	coastal
10	Bolshe Khekhtsirski Zapovednik	475.6	Khabarovsk	Zapovednik	northern	inland
11	Tigrini Dom	2069.6	Khabarovsk	unprotected	northern	inland
12	Matai River Basin (Zakaznik)	2487.6	Khabarovsk	new zakaznik	northern	inland

Table 2. Characteristics of monitoring units for tiger monintoring program.

	Protected (zapovednik)		Unprotected		
	Inland	Coastal	Inland	Coastal	Total
Southern	1	1	1	3	6
Central	0	1	3	1	5
Northern	1	1	3	0	5
Total	2	3	7	4	16

Summarizing the count units on the basis of the environmental variables outlined above shows that the resulting distribution of sites is well dispersed in a north-south gradient (6 southern, 5 central, and 5 northern) and the inland versus coastal gradient (9 inland, 7 coastal). Included as monitoring units are all 5 zapovedniks that have potential tiger habitat. Obviously, location, size, and number of protected areas were not variables we could determine or randomize, limiting the extent to which we could develop a balanced design (Table 2). An imbalance of this design exists in the distribution of unprotected sites in inland versus coastal areas (7 versus 4), but we were constrained here by personnel and infrastructure capacities in selecting sites. In Khabarovsk (northern section), there is little coastal habitat for tigers, and access is very difficult. Hence, except for Botchinski Zapovednik, no effort has been made to monitor the northern coastal region.

3. How should data be collected within Monitoring sites?

Use of survey routes.

Forty years of experience surveying tigers in the Russian Far East has demonstrated that counting tracks encountered while snow is on the ground along well-placed routes can be an effective means of describing the distribution and numbers of tigers in a region. Unlike other tiger range, in the Russian Far East the snow cover afforded in the winter season provides a "clean pallet" which reveals presence of tigers, and usually retains that evidence for an extended period, usually until the next significant snowfall.

Location of survey routes.

Two potential approaches exist for positioning routes: either distribute them randomly throughout a given count unit as a non-biased indicator of the presence of tigers within the region, or place them along routes that have the highest probability of encountering tiger tracks. Because our interests lay in the ability to detect changes over time, it is more important that there be a high probability of tiger tracks being encountered along routes. If a large percentage of routes are devoid of tracks, there is no means of detecting changes in tiger numbers. Therefore, we sought to locate routes to have the greatest chance of intersecting tiger tracks, and to minimize the number of zero counts. Maximum efficiency of encountering tracks can be achieved by positioning routes along trails, ridgetops, roads, or natural travel corridors where tigers are most likely to travel (Matyushkin 1990).

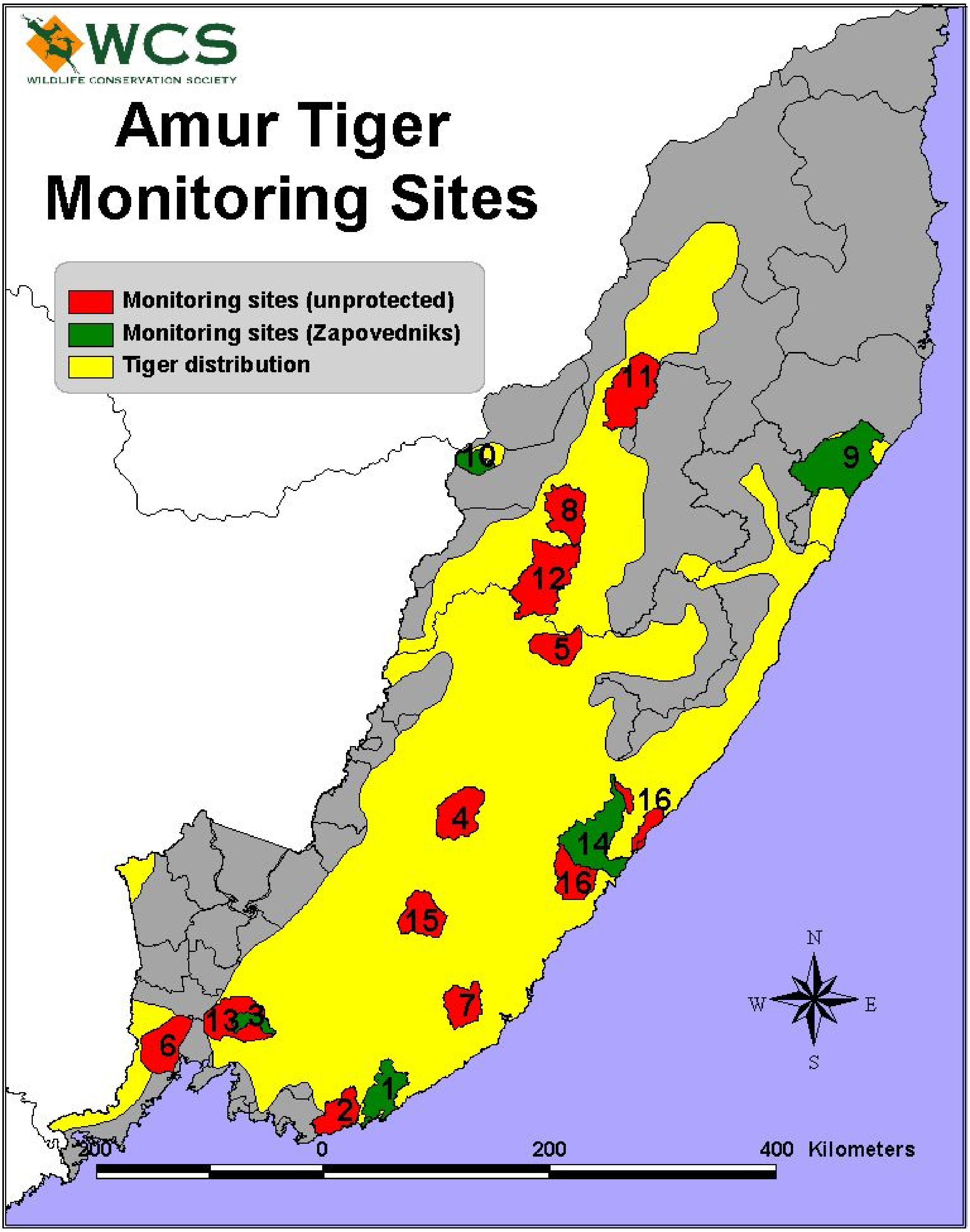

Figure 1. Location of the 16 sites used for monitoring Amur tigers in the Russian Far East. Numbers referenced in Table 1 and most other tables throughout text.

Route length

Routes should be sufficiently long so as to have a high probability of encountering tracks, and should be of a length sufficient to reduce the variability of tracks encountered per route. However, determination of appropriate length is always a trade-off between the appropriate length for statistical rigor, the financial cost of conducting surveys with different route lengths, and the amount of time (money) that can be invested in covering routes. Ideally, we should select the shortest route length that will result in only a small percentage of routes without tiger tracks, and that is sufficiently long enough to reduce the variability in number of tiger tracks per route. When variability in track density among routes is high, our ability to statistically detect changes in tiger abundance decreases.

To attempt to determine the optimal route length, we used data developed in an initial experimental stage of this program at Sikhote-Alin Zapovednik (Hayward et al. in press), and conducted a set of tests to determine effect of route length first on presence/absence data (i.e., how does changing route length change the proportion of routes with zero counts?), and secondly on track density data (i.e., how does changing route length affect the variance associated with track density data).

Effect of route length on zero counts. Trend analysis procedures using linear regression do not perform well when the proportion of zero counts is high. Therefore, we employed both field and simulated data to examine the relationship between zero counts and route length.

Null model. To determine the functional form (e.g. linear or exponential decrease) of the relationship between zero counts and route length we simulated surveys in a model 60 x 60 km 'landscape'. For each computer simulation, two 'tiger trails' were randomly placed in each 10 x 10 km grid and 4 survey routes of a designated length (from 1 to 35 km long) were placed in the landscape with a random starting point and random direction. To avoid surveying 'outside' the landscape, route starting points were constrained to begin within the inner 20 x 20 km grid squares. Intersection of simulated tiger trails and survey routes were counted to determine the number of tiger detections for 2000 iterations for each of 25 route lengths to generate the function relating proportion of zeroes to route length.

Simulated track counts demonstrated that the proportion of zero counts should decline as a negative exponential as route length increases. The parameters for the function would be situation-dependent but clearly the probability of obtaining a count of zero will tend to be smaller when route length is longer and the shape of the function is similar to a negative exponential.

Analysis of field data. We also examined field data from survey routes to determine the relationship between zero counts and both route length and days since snow. We also compared the empirical data to the relationship developed in the simulation model. Patterns were compared qualitatively (visual inspection of plots of proportion zero counts vs. route length) rather than formally testing the similarity of the distributions because we were interested in whether the patterns were similar in shape rather than whether they reflect the same theoretical distribution.

Based on data from surveys, the relationship between zero counts and route length was not similar to the pattern observed with simulated data. As expected, increases in route length resulted in fewer routes with no tiger tracks (Table 3). However, the proportion of zero counts from field data for route length demonstrated a convex declining function rather than the concave function of the negative exponential. For both variables, a linear model fit the data better than a model when the independent variable was log-transformed (a negative exponential model) (proportion zero counts to route length for linear model, R^2 = 0.945, F = 34.312, P = 0.028; and for exponential model R^2 = 0.753, F = 6.095, P = 0.132).

Table 3. Relationship between proportion of zero counts and route length for surveys conducted on foot from 1995-1999 in Sikhote-Alin Zapovednik.

Route length (km)	n	Proportion zeros
0-5	207	0.652
5-10	220	0.573
10-15	87	0.494
>15	19	0.211

Relationship between route length and variance of track density data. We explored the relationship between variance in the track density index and route length in two ways. Based on a direct analysis of 427 routes surveyed in Sikhote-Alin Zapovednik, we evaluated variation in the track index in relationship to route length. Using this approach, sample size differed greatly among distance categories (for instance there were 172 foot surveys 0-5 km long but 66 foot routes 10-15 km) and long survey routes were rare, making it difficult to estimate variation of longer routes.

To examine variability in the track index without the constraints of sample size imposed by the field data, we created a simulation data set with equal samples sizes (n = 5000) by randomly combining up to 5 routes from field data to create new routes that fell within one of 6 length categories (0-2.9, 3-5.9, 6-11.9, 12-23.9, 24-47.9, 48-96 km). Variability in counts of tiger crossings was examined for both the original and artificial data set by calculating the standard deviation and coefficient of variation in the track index for each length category.

As expected, variability in the track index, as measured by its coefficient of variation, declined with longer routes (Table 4). However, the standard deviation did not decline with increasing route length. The simulated data combining individual survey routes further demonstrated the pattern of decline in variance as route length increased (Table 5). These simulations suggest a dramatic decrease in variability between the first two distance categories with a negative exponential decline in variability thereafter. The pattern suggests only marginal reductions in variance could be realized from the extreme effort necessary to produce long survey routes.

Table 4. Relationship between variability in the tiger track index with route length based on field surveys of Amur tigers in Sikhote-Alin Zapovednik. Variability in the track index is represented by the standard deviation and coefficient of variation from a sample of 427 foot routes conducted from 1995-1999.

Route length (km)	Standard deviation	Coefficient of variation
0-5	0.0435	2.376
5-10	0.0589	2.293
10-15	0.0450	1.983
>15	0.0511	1.357

Summary of analysis of route length. Longer route lengths result in decreased variance and smaller percentages of routes with zero counts. However, feasible route length is limited by the realities of travel time and human endurance. It is clear from the above analyses that short routes should be avoided. If each route represents a sample unit, it will be imperative to successfully conduct counts on each route each year, independent of weather conditions. In deep snow years, there are situations where it is unlikely that a field worker can cover more than 15 km. Therefore, we recommend route lengths average 10 to 15 km in length.

Table 5. Relationship between route length and variability in the track index from 30,000 simulated track count surveys developed from actual field data.

Route length (km)	Track index		
	mean	SD	CV
0-3	0.198	0.7141	3.59
3-6	0.162	0.3181	1.95
6-12	0.150	0.2828	1.88
12-24	0.151	0.2121	1.40
24-48	0.153	0.1484	0.97
48-96	0.154	0.1061	0.69

Number of routes per site

The number of routes per site should be based on the following considerations: 1) there should be sufficient number of routes to have a high probability of encountering tracks of all tigers within the count unit (to allow for expert assessments of number of tigers); and, 2) there should be sufficient number of routes to provide a statistical basis for comparisons among count units and within a count unit over years.

We examined the statistical power of a monitoring program with different numbers of routes (see section 11 below), and determined that with 10 routes per count unit there is a 90% chance of statistically detecting a 10% decrease in population size (using density of tiger tracks as an indicator of tiger abundance) (see Table 9, in section 11). Chances of detecting a 5% change are decidedly less with 10 routes (45%). Increasing the number of routes to 20 increases the chance detecting a 10% decrease to 98%, but would represent a doubling of effort for a relatively modest gain. Therefore, we decided that our goal would be to establish 10-20 routes/count unit.

Method of transportation

Initial analysis of data from Sikhote-Alin (Miquelle and Smirnov 1995) indicated that there may be differences in detection rate of tiger and ungulate tracks dependent on the mode of transportation. Because we are primarily interested in monitoring changes in track density along each route for each year, variation in detection rate is acceptable between routes, but not in one route over years. Therefore, it is preferable that for each route the same mode of transportation (on foot, snowmobile, or vehicle) be used every year, for each survey, under all conditions.

Continuity of Personnel

People selected for the monitoring program should be selected on the basis of their experience in the region, their knowledge of tigers, and the probability of their continuing to participate in the monitoring program in the future. Stability in track counts will depend on retaining the same personnel over many years. Therefore, every effort has been made to retain the same coordinators and fieldworkers in each monitoring unit.

4. When should monitoring be conducted?

Timing of a monitoring program is vitally important. We consider three temporal issues in determining timing of the monitoring program.

4.1. How often, on a yearly basis, should the monitoring program be conducted?

Because statistically rigorous detection of trends in wildlife populations is difficult, the more often sampling is conducted, the greater the probability of detecting trends. Monitoring should be conducted every year, with the exact same protocol, to collect sufficient information to recognize trends in tiger numbers, prey numbers, and/or reproduction rates of tigers.

4.2 Should sampling be repeated within a year, or should increased number of samples (routes) be included at count units?

It is well known that counts of rare, secretive animals that occur in low numbers across a large area result in great variability because there are many parameters that affect the probability of encountering any one animal. Given these constraints, it is nearly impossible to count the entire population with a single simultaneous survey of all routes. An analysis of repeated surveys in Sikhote-Alin Zapovednik, where it is possible to check if radio-collared animals were included in a count, indicated that in a single, simultaneous count, as few as 20%, and up to 100%, of the tracks of known animals were encountered along routes. This variability in simultaneous counts makes it particularly difficult to monitor changes in tiger numbers between years, because it is impossible to determine whether differences in survey results reflect real changes in tiger numbers or simply fluctuations in ability to detect presence of animals.

Two ways to reduce the amount of variation between years are: 1) to saturate a count unit with greater numbers of routes for a single simultaneous survey in the hope that there will be more consistent detection of tigers. This approach may be helpful, but there are at least two reasons why a saturation approach may prove ineffective in reducing variability. First, because tigers are so mobile, part of the variation is due to the fact that some percentage of tigers is simply not present on the count unit during any single survey. Secondly, because tigers can stay on kill sites for up to a week, moving less than 100 meters, even with a very large number of routes some tigers could be missed in a single survey.

The second possible approach is to repeatedly survey a count unit within a given year. This process greatly increases the cost of the survey, but should also greatly increase the probability of encountering all tigers that use a count unit in the course of a winter, and should therefore greatly decrease inter-year variation in count accuracy.

We have selected to conduct two surveys of each count unit each winter – once early in winter (December-January) and once closer to the end of winter (mid-February).

4.3 When should routes be covered in relation to snowfall?

We used the same approach for analyzing zero counts for presence/absence data and variance in track density data as for assessing the effect of route length. Based on data from surveys, the relationship between zero counts and days since snow was not similar to the pattern observed with simulated data (comparing Tables 6). As expected, increases in days since snow resulted in fewer routes with no tiger tracks. However, the proportion of zero counts from field data resulted in a convex declining function rather than the concave function of the negative exponential. A linear model fit the data better than a model when the independent variable was log-transformed (a negative exponential model) (R^2 = 0.969, F = 63.315, P = 0.015 for a linear model and R^2 = 0.815, F = 8.787, P = 0.0975 for the negative exponential model).

Variability in the track index, as measured by its coefficient of variation, declined with greater intervals since snowfall (Table 7). Standard deviation also declined in relation to days since snow (Table 7).

Table 6. Relationship between proportion of zero counts and days since snow for surveys conducted on foot from 1995-1999 in Sikhote-Alin Zapovednik.

Days since last snow	n	Proportion zero
1-4	147	0.680
5-8	90	0.633
9-12	110	0.527
≥13	90	0.411

Table 7. Relationship between variability in the tiger track index with route length and days since snow based on field surveys for Amur tiger in Sikhote-Alin Zapovednik. Variability in the track index is represented by the standard deviation and coefficient of variation from a sample of 427 foot routes conducted from 1995-1999.

Days since last snow	Standard deviation	Coefficient of variation
1-4	0.0755	2.227
5-8	0.0374	2.143
9-12	0.0285	1.802
≥13	0.0275	1.478

Results of these analyses demonstrate that conducting surveys immediately following snowfall results in a higher proportion of sample routes with no tiger tracks, and a higher variance of track density estimates, making it more difficult to detect real trends in the tiger population. Standard deviation of track density estimators decline dramatically if counts are conducted at least 5 days after snow. While the coefficient of variation shows its greatest drop when 9 days have passed since snowfall, at least in some years, when snows are common, waiting 9 days after a snowfall to initiate survey work may be difficult. Surveys conducted 9-12 days after snowfall may be ideal in terms of encounter rate, but this plus must be weighed against track disintegration (see above). Therefore, we recommend that surveys be conducted 5-10 days after snowfall, whenever possible. This time frame strikes a balance between reducing the proportion of zero counts, and reducing variance estimates, and the loss of information due to track disintegration.

5. What should be measured as an index of tiger productivity?

Data on number of litters, number of cubs, and litter size are reported for each site as part of the estimate of tiger numbers by coordinators. We summarize this data across all sites to develop an estimate of productivity for the year. There are four types of information that can be derived as indicators of tiger productivity:

1. Number of litters. We can compare the total number of litters produced across all sites combined over time, and can compare number of litters produced within each site over time.

2. Number of cubs. We can compare the total number of cubs produced across all sites combined over time, and can compare number of cubs produced within each site over time. However, because count units vary in size, it is better to use a standardized variable, such as cub density, that accounts for this variation in comparisons among sites (see #3).

3. Cub density. We prefer to report cub density (number of cubs reported for a site divided by area of the monitoring site), rather than simply the numbers of cubs, as a parameter for comparison across years and sites. This variable provides a basis for determining trends and allows for statistical testing.

4. Litter size. Litter size is often an indicator of the nutritional status of the mother, and is an important variable affecting overall productivity. Changes in litter size over time are indicator of shifts in productivity. However, because litter size varies dramatically with the age of the litter (with much mortality occurring in the first 3 months) interpretation of this data must be done carefully.

6. What should be measured as an index of prey abundance?

Good estimates of actual prey abundance require extensive work to acquire, and would become a major expense of a tiger monitoring program. Instead of trying to estimate actual density, we decided to use track density as an indicator of relative abundance of ungulates. At the same time, we are attempting to develop relationships between track density and actual animal abundance. In the meantime, changes in track density should, over time, act as an adequate indicator of changes in population numbers over time. Actual track densities show great variability over a season, and among routes covered within any single count unit. Therefore, we believe that double sampling (early winter and late winter) is a key component of the methodology to reduce variability, not only of tiger tracks, but of ungulate tracks as well.

7. How should mortality be monitored?

We recommend that reports of mortality should be included in a monitoring program in two formats: official reports, and unofficial reports.

Official mortality reports. Each year, the Ministry of Natural Resources is responsible for reporting all officially acknowledged deaths of tigers. This report provides information on only a small portion of the actual number of deaths, but its value lies in the fact that these mortalities have been thoroughly investigated and confirmed. For the most part, these deaths are usually related to a conflict or encounter with humans, and therefore provide an indicator of the number of mortalities related to human-tigers conflicts that can be monitoring over time.

Unofficial mortality reports. Each coordinator is responsible for collecting information on deaths of tigers in or in proximity to count units. In many cases, these reports cannot be confirmed, as coordinators often have to assure confidentiality to obtain the data. Thus, there are no doubt errors associated with this reports, but they nonetheless act as a "barometer" of tiger mortalities, again usually human-caused, that are occurring in and around count units within a given year. As such, they provide valuable information on the impacts of humans on tigers, and on the mortality rates for a given region. These data provide a different and very valuable perspective on tiger mortalities in comparison to official reports, and likely provide an estimate closer to actual mortality rates than official reports.

8. How should habitat changes be monitored?

A first step in defining count units is development of a passport, which should include the following information: boundaries, total area, vegetation cover, number of roads, area logged, forest cover types, locations of commercial objects, and villages in the area. The purpose of this table to record changes that have occurred in the past year.

We have derived a set of questions to determine changes in habitat quality for tigers and their prey on count units. Yearly monitoring is focused not so much in specifying exact conditions on count units, which would be a time consuming and difficult process, but identifying changes occurring on the unit. Therefore, nearly all questions seek to determine if changes have occurred, whether than to specify exactly what conditions exist. The questions relate to logging, fire, hunting, livestock use, and overall human use of the count units. Most questions that seek to quantify the level of activity require only categorical responses (e.g. we have 5 categories as potential responses to the question "How much logging has occurred on the count unit this past year?" ranging from none to greater than 1000 ha.). The questions are formulated as follows:

1. Have any new roads been built in the count unit this year? If so, how many kilometers?

2. Has there been repairs/reopening of any roads in the past year (e.g. asphalt)?

3. Have any roads been closed in the count unit this year?

4. Has logging occurred on the count unit this year? If so, what types and how many hectares

5. How many villages are there within 30 km of the count unit?

6: How many people are living within 30 km of the count unit?

7: Has there been a change in the number of people within 30 km of the count unit in the past year?

8. Specify type of fires (grass fire, crown fire) and area burned within your count unit this past year.

9: Report the number of livestock that have pastured on the count unit in the past year (total number of animals – not total number of days grazed).

10. Has the number of livestock using the count unit changed from last year?

11: Number of reports of depredation by tigers on livestock within the monitoring site, by species

12. Provide an estimate of the human disturbance factor on the count unit (number of person days on the count unit per month, for the months during which the monitoring program was conducted.

13. How many hunting licenses were provided for the count unit this year?

14. In your opinion, has the number of illegal shootings of ungulates increased or decreased from last year?

15. Estimate the number of illegal shootings of ungulates on your count unit this year.

16. In your opinion, has the number of illegal killings of tigers increased or decreased from last year?

17. In your opinion, has the status of tiger habitat on your count unit increased or decreased from last year.

18. Have there been any other changes on your count unit that may have an impact on the tiger population or tiger habitat?

9. How should data be stored?

A key component of creating a reliable, long-term monitoring program is the development of a means of storing and analyzing data. We have invested substantial finances and energy into developing a spatially explicit database in a standardized format that will insure long-term protection of the database, and at the same time provides relatively easy access for analysis. We have developed the database in Microsoft ACCESS that linked to a specially edited version of ArcView (ESRI Corp.) that contains all data collected by fieldworkers on every tiger track and individual, tiger deaths, route information (ungulate densities are reported by route), and count unit. The first two years of the program were spent in developing the database, and creating ArcView interface that spatially links the attribute data. Each count unit is defined by a series of "coverages" that includes: boundaries of count unit (and boundaries of protected areas), the river system, for most count units a forest cover map, location of survey routes, tiger tracks (coded by sex and age when possible) location of females with cubs, and sites of mortality. The MS ACCESS database exists as a series of linked tables, making analysis relatively easy, and the ArcView interface provides the opportunity to quickly visually assess the data and obtain necessary information. The ArcView project exists in two scales: 1) 1:500,000 for general reference to the entire range of tigers; and 2) 1:100,000, which is the scale used for recording and entering data on specific count units. The database now exists in a specially designed format (using AVENUE) so that data entry is possible without technical expertise in ARCINFO, or the need for digitizing data.

10. How should data be analyzed?

While an approach based on sampling provides the benefits of lower cost, more frequent implementation, and better measures of accuracy, there are problems. Counts of rare objects generally result in estimates with large variances. This leads to the potential for estimates that lack the level of precision necessary to make critical management decisions. Therefore, careful attention needs to be paid to how data can and should be analyzed.

We sought to determine trends in tiger populations and their key prey resources by assessing spatial and temporal variation in the following parameters:

Relative tiger abundance

We used three indices of relative tiger abundance: presence/absence of tiger tracks on survey routes (expressed as the percentage of routes within each count unit with no tiger tracks recorded); track density, adjusted for number of days since last snow; and "independent tiger" density. The mean and standard deviation of the first two indices for each site can be derived using each route as a subsample fore the site. The expert assessment of number of tigers exists as a single value (expressed as density of "independent tigers" with no error term (i.e., we have not derived a means of assessing error for expert assessments). These three sets of data can then be used to make the following comparisons:

Changes over time in tiger abundance across the entire range, and changes in tiger abundance indices over time for each count unit separately. We conduct linear regression analyses for all sites combined (to give an indication of trends for the entire Amur tiger population) and each site separately (to look for trends within each site). The same types of analyses are conducted for presence/absence data, tiger track density, expert assessments of tiger density, and track data for ungulates (see below). The intent of the regression analyses is to identify trends over time in the population across the whole region, and within each of the monitoring sites. We have defined sites as "areas of concern" if the trend analyses demonstrates a negative slope for which the statistical probability was greater than 80% (i.e. $P < 0.2$) that the population was decreasing (i.e. that the slope of the line did not equal zero, i.e., $\beta \neq 0$). We have used the same criteria for defining sites as "areas with positive growth indicators" if the slope is positive.

This is a very conservative approach, as most statisticians use a P value of 0.05. By increasing the P-value to 0.2, we dramatically increase the probability of defining a site as an "area of concern" or an "area with positive growth" when in fact such may not be the case. We use this more conservative approach because we argue that we must have a mechanism for identifying areas early, so that remedial action can take place: a more liberal approach (with a smaller P value) would result in fewer "false alarms" but may not identify all areas in time to respond on an appropriate time scale. We balance this conservative approach by using a suite of indicators (3 for tigers, and one for each species of prey). We consider trends to be occurring in the tiger population (for the entire population or for any individual site) if two of the three indicators demonstrate a similar pattern (i.e., decline, growth, or stability in population status).

By assessing a host of variables, we believe the approach provides a balance between being overly alarmist and overly complacent.

Differences in tiger abundance among sites in any given year (or over all years). To assess whether variation in tiger abundance (for any of the three indicators) exists among sites in any given year (or all years combined), we employ a non-parametric analysis of variance using the ranks of each indicator. In most cases we use a non-parametric approach because the indicator values are not normally distributed. The results of the ANOVA F-test will determine if there are significant overall differences among sites, but will not provide a means of determining which sites are different from each other. To do that requires a "multiple comparison" test. We employ either protected LSD test – conducting the Fishers Least Significant Difference test (LSD test) only if the overall ANOVA is significant, or conducting a Tukey's "honestly significant difference" pair wise comparison test (as defined in SAS 1985)

The effect of environmental/geographic parameters on tiger abundance indicators. We assess the importance of environmental parameters in explaining variation in tiger abundance indicators by conducting a 3-way unbalanced factorial ANOVA, with protected status, latitude, and proximity to coast as independent variables. If the distribution of the tiger abundance indicator data is not normal, we first rank the values of the indicator for each count unit, and then conduct the same factorial analysis of variance on those ranked values. If the overall ANOVA is significant, we use one of the multiple comparison tests described above to test for differences within any one of the three parameters.

Paired comparisons of zapovedniks and adjacent unprotected territories. Paired comparisons of the 3 zapovedniks with adjacent monitoring sites (i.e., Ussuriski Zapovednik versus Ussuriski Raion, Lazovski Zapovednik versus Lazovski Raion, and Sikhote-Alin Zapovednik versus Terney Hunting Society) provide a means of comparing adjacent sites that retain similar characteristics, with the only major difference being protected status. Using these three pairs provides a clear demonstration of the importance of protected status and its impact on tiger and ungulate abundance indices.

The relationship of these three tiger abundance indices to each other. We compare how well the three tiger abundance estimators (presence/absence, track densities, tiger densities) correlate with each by ranking each site by its relative value for each of the estimators, and estimating Spearman's rho (Conover 1980) on those ranks.

Changes in the tiger productivity

Data on number of litters, number of cubs, and litter size are reported for each site as part of the estimate of tiger numbers by coordinators. We summarize this data across all sites to develop an estimate of productivity for the year. However, because sites varied greatly in size, we could not use simply the total number of cubs or litters as a parameter for comparison across years and sites. We instead used cub density (number of cubs divided by area of the monitoring site) as a measure of productivity to compare among sites and as a constant that could be used for analyses of trends across years.

Changes in prey populations

Relative abundance of the 4 primary prey species of tigers (red deer, wild boar, roe deer, and sika deer) is estimated on the basis of number of fresh (< 24 hours old) tracks intersecting survey routes. Estimates from both surveys in each winter (early and later winter surveys) are averaged to derive an estimate of mean number of tracks, for each species, that intersect each route for the winter. Each route acts as a sampling unit to develop a mean for the monitoring site. That mean value is used to conduct a trend analysis similar to that conducted for the tiger abundance indices (see above) for each site separately and for all combined. For each species, we conducted a separate a 3-way factorial model to assess environmental parameters (latitude, protected status, and proximity to coast).

11. Does the design of the monitoring program permit a reasonable statistical probability of detecting trends that may occur in the population index?

Introduction to power analysis

Our analysis assumes that trend will be examined using regression methods by testing for a significant slope coefficient based on a t-test of the null hypothesis that $B_1 < 0$ (Gibbs 1995, Gerrodette 1987, Thompson et al. 1998). Although other statistical approaches could be employed, we based our analysis on this method because its applicability for monitoring vertebrate populations has been thoroughly assessed in recent literature (see review in Thompson et al. 1998). Other approaches, such as dividing the time series into 2 or 3 intervals and testing for differences using a Wilcoxon signed rank test or employing graphical methods may also be useful. However, examining statistical power and other features of the pilot data employing regression provides a focus for analysis to assist in field protocol design.

We used Monte Carlo simulations to determine how route length, number of routes, and alpha (probability of a Type I error) influence power. Using the program MONITOR 6.2 (Gibbs 1995) we generated 10,000 simulations of track indices over a 5-year monitoring horizon to estimate power to detect an annual change in track index of +10%, +5%, no change, -5%, or -10%. The analyses assume that tiger tracks will be counted on routes for 5 years and trends assessed with a linear regression model of log-transformed track indices. We followed Thompson et al. (1998:160) and chose to model exponential, rather than linear population growth (or decline) because this model is expected to most closely approximate demographic processes of tiger populations.

Input values for the simulations were based on statistical summaries of surveys from Sikhote-Alin Zapovednik from 1995-1999. The simulations require a mean track index and standard deviation for each simulated route. A specified trend (say 5% decrease) is simulated by extrapolating an annual 5% decline, beginning with the specified mean index and then generating random index values, each year, for five years. The generated indices are drawn from a normal distribution whose mean is equal to the deterministic projection for a particular year and standard deviation based on the estimated value from our field studies. Most simulations assumed sampling from multiple routes to determine trend. Because trend would be expected to vary among sites within a region, we assumed that the standard deviation describing trend variation among sites would equal 0.015. This value is based on the standard deviation of the mean track index from 15 survey areas sampled in our field surveys. Because power to detect regional declines will be higher if one-tailed tests are employed and because ability to detect declines is of paramount importance, we examined the influence of monitoring design criteria on power for one-tailed tests assuming $\alpha = 0.20$.. Input parameters for route length, number of routes, and alpha are described below.

Route length. The mean and standard deviation for the track index from survey routes were used for each of five length categories (0-5, 5-10, 10-15, 15-20 and 20-25 km). Each simulation examined index values over five years from a single route sampled twice each year. We focus on a sampling design that surveys each route twice a year because this provides a link to information collected in the past from the traditional census.

Number of routes. We examined the power of a monitoring system to detect a trend based on 3, 5, 10, and 20 routes. We used track index values corresponding to a mean route length of 8 km from the field surveys, $\alpha = 0.20$, and a one-tailed test.

Alpha, probability of type I error. We examined the extent to which power increased as α is increased by comparing $\alpha = 0.05$, 0.10, 0.15 and 0.20. For these analyses we simulated a monitoring design employing 10 routes monitored twice each year for five years.

Results of power analysis to detect trends in tiger tracks

Route length. Power increased with route length (Table 8). Based on the variance structure of data from survey routes, the most substantial improvements in power are realized by extending route length from 17.5 to 22.5 km.

Number of routes. Results demonstrate that it is difficult to detect a significant change in tiger tracks based on a single route (Table 8). Results also illustrate that it will be difficult to achieve sufficient power to detect a 5% annual change in tiger track counts even with a sample of 20 routes monitored within any region (Table 9). However, given a 10% annual trend, adequate power is achieved with a sample of 10 routes. The most substantial gains in power are achieved by increasing sample size from 3 to 10 routes. Monitoring more routes results in relatively modest increases in power if seeking to detect a trend of $\pm$ 10%.

Alpha, probability of type I error. Results demonstrate that a significance level (α) below 0.15 will achieve unacceptable power for all effect sizes (Table 10). Decisions regarding choice of (α) will depend on judgment regarding the effect size to monitor and the perceived consequences of Type I error vs. Type II error.

Table 8. Relationship between route length and probability of detecting a trend (power) using regression analysis of tiger track index from a single monitoring route. Trend refers to the annual proportional change in the track index (effect size) that the monitoring program wishes to detect. Analysis is based on mean track index and standard deviation calculated from 427 foot surveys conducted from 1995-1999 in Sikhote-Alin Zapovednik. Mean and STD refer to the mean index for each route length and the standard deviation of that value calculated from the field surveys.

Trend	Route length				
	2.5 km	7.5 km	12.5 km	17.5 km	22.5 km
-0.1	0.409	0.407	0.404	0.421	0.503
-0.05	0.292	0.301	0.293	0.295	0.337
0	0.200	0.188	0.201	0.197	0.197
0.05	0.305	0.302	0.299	0.304	0.348
0.1	0.415	0.415	0.400	0.434	0.528
Mean	0.0187	0.0213	0.0177	0.0196	0.0150
STD	0.03790	0.04148	0.03800	0.02988	0.01126

Table 9. Relationship between number of routes monitored and probability of detecting a trend in tiger track index based on foot surveys. See table 6 and text for further details.

Trend	Number of Routes			
	3	5	10	20
-0.1	0.593	0.724	0.892	0.984
-0.05	0.391	0.456	0.583	0.753
0	0.194	0.197	0.200	0.196
0.05	0.382	0.458	0.592	0.756
0.1	0.608	0.737	0.908	0.988

Table 10. Influence of alpha (level of significance) on power in a test of trend in a tiger track index based on 10 routes surveyed twice each year for 5 years. See table 6 and text for details.

Trend	Alpha (α)			
	0.05	0.10	0.15	0.20
-0.1	0.624	0.771	0.847	0.887
-0.05	0.258	0.399	0.504	0.586
0	0.048	0.096	0.156	0.199
0.05	0.266	0.406	0.503	0.586
0.1	0.653	0.793	0.855	0.901

Summary

Our results suggest that track counts can be employed as part of a system to monitor Amur tiger abundance given the critical assumption that changes in track counts reflect changes in tiger population size. A monitoring system employing 10 to 20 routes, 12 to 15 km long, sampled twice each year could provide over 80% power to detect a 10% annual decline in tiger tracks with a 20% chance of "false alarms" ($\alpha = 0.20$).

Each of the three indicators of tiger abundance has their problems. The exact relationship between numbers of presence/absence counts, track density, and expert assessment of tiger numbers, to the REAL number of tigers is unknown. This critical relationship between an index and population abundance has not been tested and application of an unvalidated index requires careful consideration of potential errors (Thompson et al. 1998). However, Caughley (1977) argued strongly that an index frequently provides the information needed for management. Thorough validation of our index would be extremely difficult because of significant problems encountered in executing the preferred alternative -- estimating abundance of Amur tigers.

Probability sampling (Van Sickle and Lindzey 1991, Becker 1991) and mark/recapture using genetic analysis of hair samples or camera traps represent alternative methods for directly monitoring tiger abundance (Karanth 1995, Hornocker Wildlife Institute 1998). These methods would avoid the problems encountered with an index. Logistical constraints related to aircraft availability, and an inability to detect tiger tracks in forest habitats from aircraft (especially mixed coniferous forests), have inhibited development of probability sampling with aerial surveys. In a similar way, low probability of "recapture" with low density populations may limit usefulness of mark-recapture procedures. The logistical constraints of sampling a rare animal across a vast landscape (nearly 200,000 km^2) will remain for any system employed, but large home ranges and long daily movements (Yudakov and Nikolaev 1979) of Amur tigers make probability of encountering tracks of any given animal during periods of snow cover relatively high. Use of a track index can provide statistical rigor, and act as a suitable link to the institutionalized and politically acceptable tiger counts that have been conducted in the past. Therefore, given the theoretical support for a track index to monitor other carnivores (Kendall et al. 1992, Beier and Cunningham 1996) we suggest that this index offers an acceptable monitoring tool.

If the track index represents the most feasible monitoring tool for Amur tigers, can implementation of a monitoring program using the index be defended given the realistic constraints of power, type I error rates, and the field effort? We feel the design criteria that emerge from our analysis support pursuing a program based on the above criteria. This approach provides the opportunity to monitor tiger abundance with a track index as well as to conduct other components of the traditional monitoring program (e.g. indices of reproduction, prey abundance, human impact, and tiger mortality).

Constraints associated with track degradation, in concert with variance associated with route length and time since snow help define many of the parameters for designing the monitoring program. Increasing the time since snow will decrease variance, but this factor must be weighed against the probability of track degradation due to recurrent snow, wind, or melt-out. We recommend that surveys conducted 5-10 days after snow during January and February will incur relatively little loss of tracks due to degradation, and benefit from reduced variance due to extended time since last snow.

Longer route lengths result in decreased variance and smaller percentages of routes with zero counts. However, feasible route length is limited by the realities of travel time and human endurance. If each route represents a sample unit, it will be imperative to successfully conduct counts on each route each year, independent of weather conditions. In deep snow years, there are situations where it is unlikely that a field worker can cover more than 15 km. Therefore, we recommend route lengths average 10 to 15 km in length.

Larger numbers of routes per count unit provide a greater probability of detecting trends. Based on the power analysis, we recommend that no fewer than 10 routes be located within each count unit.

A reduced sampling effort would not permit detection of declines of 10% which we feel is an effect size sufficient to require a conservation response. However, if 350 adult tigers exist in the Russian Far East, a 10% annual decline in abundance would lead to a population of about 200 tigers after 5 years; a change warranting immediate action. Therefore, given the precarious status of the Amur tiger, we feel uncomfortable recommending a smaller sample effort be employed with the goal of detecting a larger effect size. The system we recommend ($\alpha = 0.20$) would lead to a relatively high rate of false inferences that tigers are declining when, in fact, they are not. Allowing a Type-I error rate of 20% has been defended as a reasonable compromise in endangered species monitoring (Kendall et al. 1992, Beier and Cunningham 1996). Reducing the frequency of false alarms would lead directly to reduced ability to detect declines, delaying the initiation of further conservation management.

We have employed this above described methodology in implementing the Amur Tiger Monitoring Program as an experimental attempt to determine the feasibility of permanently establishing such a program. Our results demonstrate that not only can the program be successfully implemented, but that it provides a host of valuable information on tiger numbers, reproduction, mortality, that is critical to responsible management. Additionally, our methodology provides a database of assessment of the prey base upon which tigers depend, and the habitat upon which both tigers and their prey depend. Thus, we feel we have developed an effective measuring rod that will aid government officials in assessing the status of tigers, and the effectiveness of conservation measures.

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IV. RESULTS OF THE 2002-2003 WINTER MONITORING PROGRAM

Summary Data on Count Units and Routes

As in previous years, in the 2002-2003 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).

Snow depth was greater than normal in 11 of the 16 monitoring sites (Figure 1). Unusually deep snows were reported for three zapovedniks (Sikhote-Alin, Ussuriski, and Bolshe-Khekhtsirski) and unusually shallow snow reported in Matai and Borisovkoe Plateau Zakazniks, and Lazovski Raion. Other sites had snow depths closer to 4-year averages (Figure 1).

Table 1. Characteristics of units surveyed for Amur tiger monitoring program

	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	12,428049	1,30

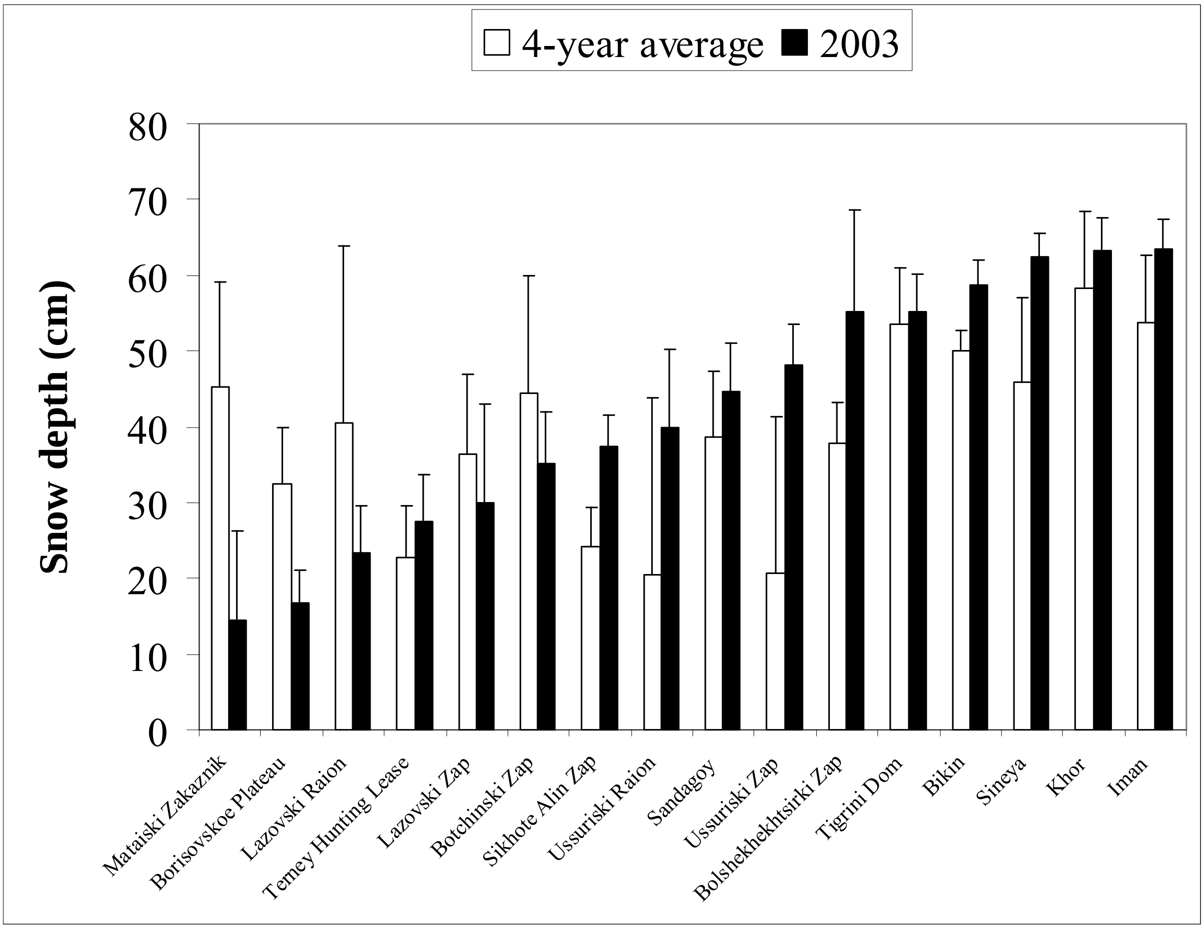


Figure 1. Snow depth on routes within monitoring sites of the Amur Tiger Monitoring Program, for February, 2003 compared to average of previous 4 years (1999-2002; data from 1998 not available).

Measures Of Tiger Abundance

Zero Counts on Survey Routes (Presence/Absence)

Reporting on zero counts on survey routes serves two purposes.

1) as noted in the Introduction, 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 zero counts on survey routes when no tracks were recorded on both the early and late winter surveys. In the 2002-2003 winter 31% of 1476 routes on monitoring sites did not intersect tiger tracks. Last year's estimate of 38% represented an all-time low, and trend analyses indicated a significant decrease in presence of tracks on routes. This year's estimate of 69% routes with tracks is close to the 6-year average of 67% (Table 2). Whereas last year there is a non-significant downward trend in the number of routes with tracks recorded, no such trend is evident with the increase reported this year (Figure 2).

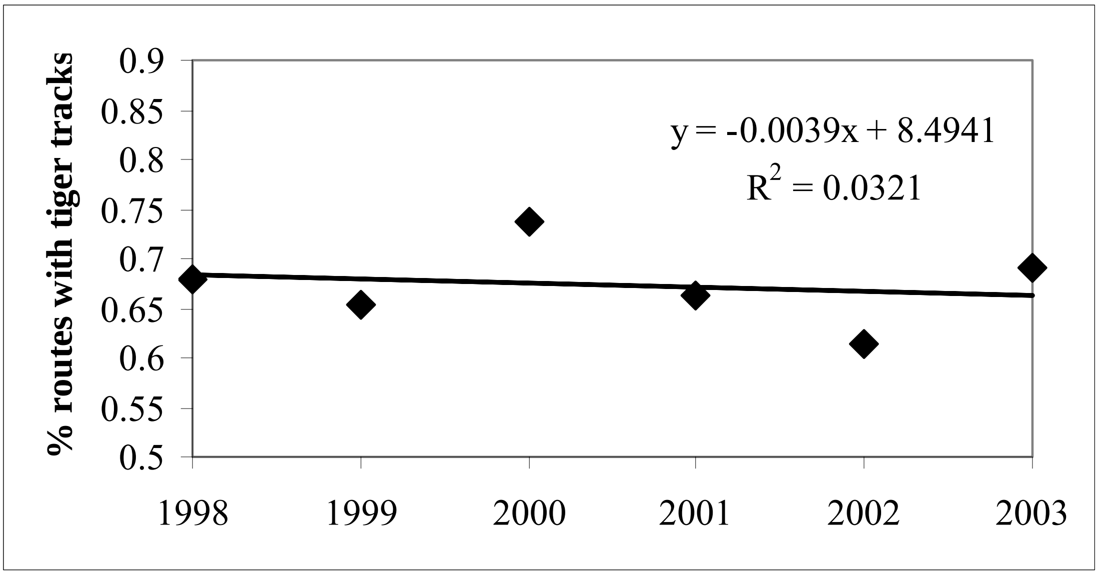


Figure 2. Overall trends in presence of tiger tracks on routes, averaged for all 16 sites of the Amur Tiger Monitoring Program, from the 1997-1998 winter through 2002-2003 winter season.

Table 2. Percentage of routes with tiger tracks present on routes in 16 units of the Amur Tiger Monitoring Program, 1997-1998 though 2002-2003.

Unit	# routes	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	6-year average
Lazovski Zapovednik	12	91.7%	83.3%	100.0%	100.0%	100.0%	91.7%	94.4%
Ussuriski Zapopvednik	11	90.9%	100.0%	90.9%	90.9%	81.8%	81.8%	89.4%
Bikin	15	46.7%	93.3%	93.3%	100.0%	86.7%	86.7%	84.4%
Lazovski Raion	11	100.0%	72.7%	63.6%	45.5%	90.9%	90.9%	77.3%
Iman	12	91.7%	66.7%	75.0%	91.7%	75.0%	58.3%	76.4%
Sikhote Alin Zapovednik	26	84.6%	76.9%	80.8%	73.1%	61.5%	76.9%	75.6%
Botchinski Zapovednik	14	64.3%	57.1%	85.7%	100.0%	64.3%	78.6%	75.0%
Tigrini Dom	14	50.0%	64.3%	71.4%	78.6%	64.3%	71.4%	66.7%
Mataiski Zakaznik	24	54.2%	79.2%	50.0%	58.3%	75.0%	70.8%	64.6%
Khor	19	52.6%	31.6%	89.5%	57.9%	68.4%	57.9%	59.6%
Ussuriski Raion	12	66.7%	33.3%	100.0%	33.3%	58.3%	58.3%	58.3%
Borisovskoe Plateau	14	57.1%	57.1%	50.0%	57.1%	50.0%	64.3%	56.0%
Terney Hunting Lease	24	66.7%	66.7%	54.2%	58.3%	33.3%	45.8%	54.2%
Sandagoy	16	50.0%	68.8%	43.8%	56.3%	18.8%	81.3%	53.1%
Sineya	15	46.7%	53.3%	46.7%	46.7%	26.7%	60.0%	46.7%
Bolshekhekhtsirki Zap	7	71.4%	42.9%	85.7%	14.3%	28.6%	28.6%	45.2%
Average		67.8%	65.5%	73.8%	66.4%	61.5%	69.0%	67.3%

Percentage of routes with tiger tracks varied from 28% (Bolshe-Khekhtsirski Zapovednik) to 100% to 92% (Lazovski Zapovednik) among monitoring units in the 2002-2003 winter (Table 2). Overall, while last year the trend analysis for all sites combined suggested a downward trend, there was a general increase in the percentage of routes with tracks across all sites combined over the past two years (Table 2, Figure 2). All five sites that showed evidence of a downward trend last year had increases in percentage of routes with tracks this year; however, those downward trends were still significant for Sikhote-Alin Zapovednik and Terney Hunting Lease (Figure 3). Additionally, two other zapovedniks – Ussuriski and Bolshe-Khekhtsirski, now demonstrate downward trends that are causes for concern (Figure 3). Of all 16 monitoring units, only one – Tigrini Dom in Khabarovsk – has shown an increasing trend in numbers of routes with tracks (Figure 3), but this may be a relict of the very low estimate in the first year. Eliminating that first year from the trend analysis indicates that track presence on routes has been quite stable across the last 5 years in Tigrini Dom.

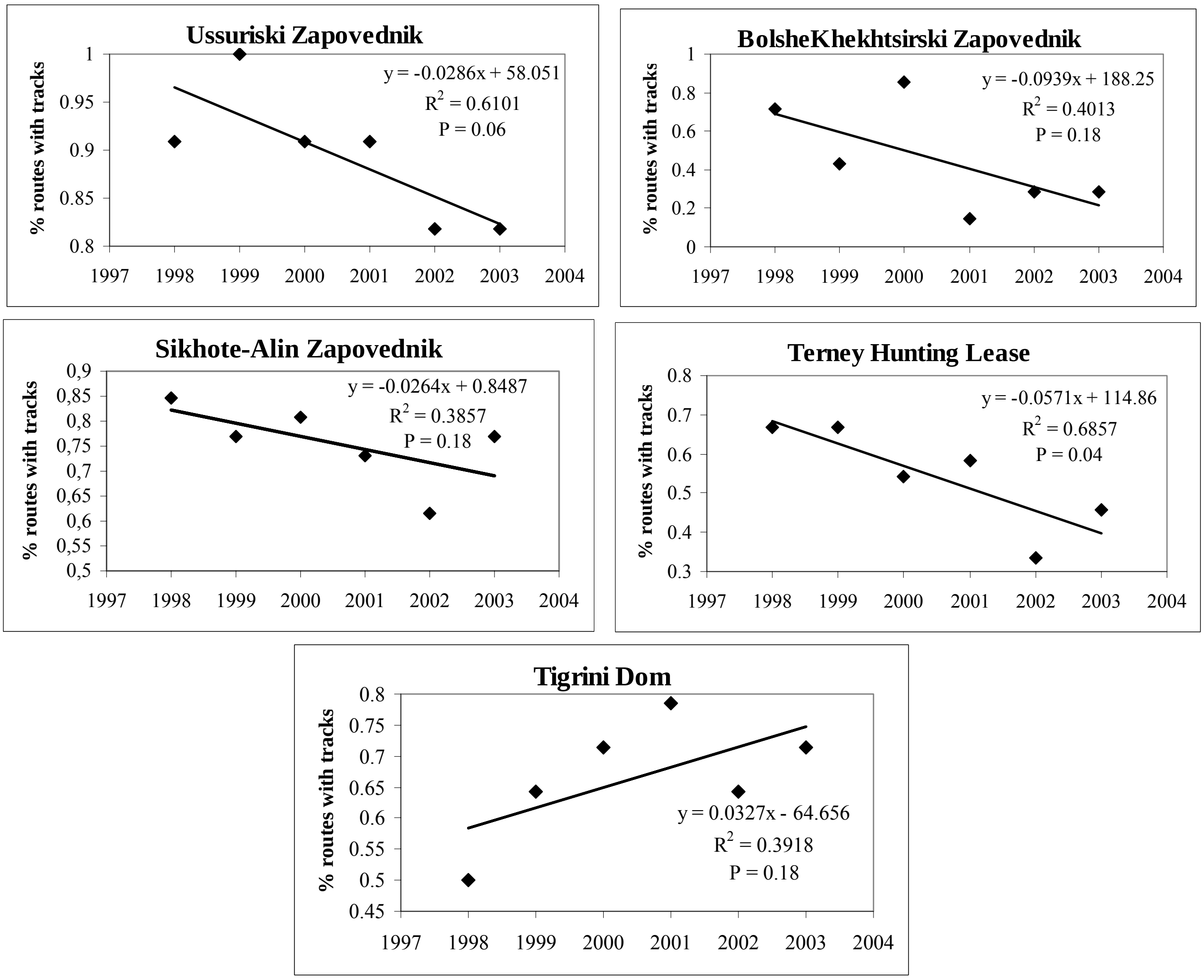


Figure 3. Monitoring units which have shown a drop or increase ($P < 0.2$ for the regression) in percentage of survey routes with tiger tracks found across all 6 years of the Amur Tiger Monitoring Program, 1997-1998 through 2002-2003 winter seasons.

Track Counts on Survey Routes

Mean track density, adjusted for the number of days since the last snowfall (see Methods), should provide an indication of relative abundance of tigers on monitoring sites (Table 3). As in previous years, estimates of track density varied greatly among monitoring sites. Overall, mean track density for all sites combined continued in a downward trend (Table 3). As in previous years, Ussuriski and Lazovski Zapovedniks ranked among the highest in track densities for 2003, but density of tracks in Sikhote-Alin Zapovednik fell from previous years (Table 3), and the two northern zapovedniks, Bolshe-Khekhtsirski and Botchinski, ranked among the lowest in track density. Track density in the Bikin monitoring site remained high (Table 3). Track density in Tigrini Dom, which had increased fairly consistently over the past 3 years of monitoring, fell in 2003 (Table 3).

Table 3. Track density (tracks/days.since snow/100 km survey routes) of tigers on 16 sites during the first 6 years of the Amur Tiger Monitoring Program.

Monitoring unit	1998	1999	2000	2001	2002	2003	Mean
Lazovski Zapovednik	3,62	2,19	3,08	3,57	2,52	3,33	3,05
Bikin	3,61	7,71	0,95	3,70	2,31	2,63	3,49
Ussurisk Zapovednik	3,28	9,66	6,45	6,15	3,49	2,62	5,27
Tigrini Dom	0,67	1,47	1,13	1,51	1,66	1,27	1,28
Borisovskoe Plateau	0,50	0,85	1,45	0,60	0,51	1,17	0,85
Sikhote Alin Zapovednik	1,99	1,28	1,52	1,18	0,91	1,04	1,32
Lazovski Raion	1,44	0,67	0,99	1,02	1,62	0,93	1,11
Sandagoy	0,47	0,66	0,34	0,41	0,23	0,73	0,47
Khor	0,44	0,80	1,67	1,50	1,35	0,73	1,08
Iman	0,96	2,81	0,86	0,76	0,81	0,65	1,14
Terney Hunting Lease	0,83	0,64	0,73	0,90	0,39	0,61	0,69
Sineya	0,24	0,33	0,47	0,58	0,38	0,58	0,43
Ussuriski Raion	1,01	0,61	1,93	1,44	1,70	0,49	1,20
Botchinski Zapovednik	0,88	0,74	1,20	1,29	1,04	0,46	0,93
Bolshekhekhtsirki Zapovednik	1,51	1,47	0,84	0,71	0,71	0,42	0,95
Mataiski Zakaznik	0,63	1,18	0,73	2,42	0,38	0,39	0,95
Yearly mean	1,38	2,07	1,52	1,73	1,25	1,13	1,51

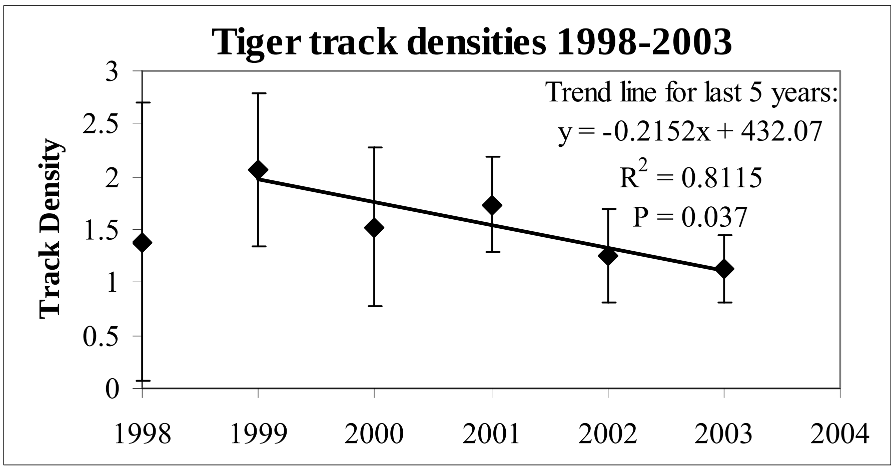


Figure 4. Density of tiger tracks (tracks/100 km/days since last snow) as indicators of tiger abundance averaged across 16 sites included in the Amur Tiger Monitoring Program; trend line estimated for past 6 years.

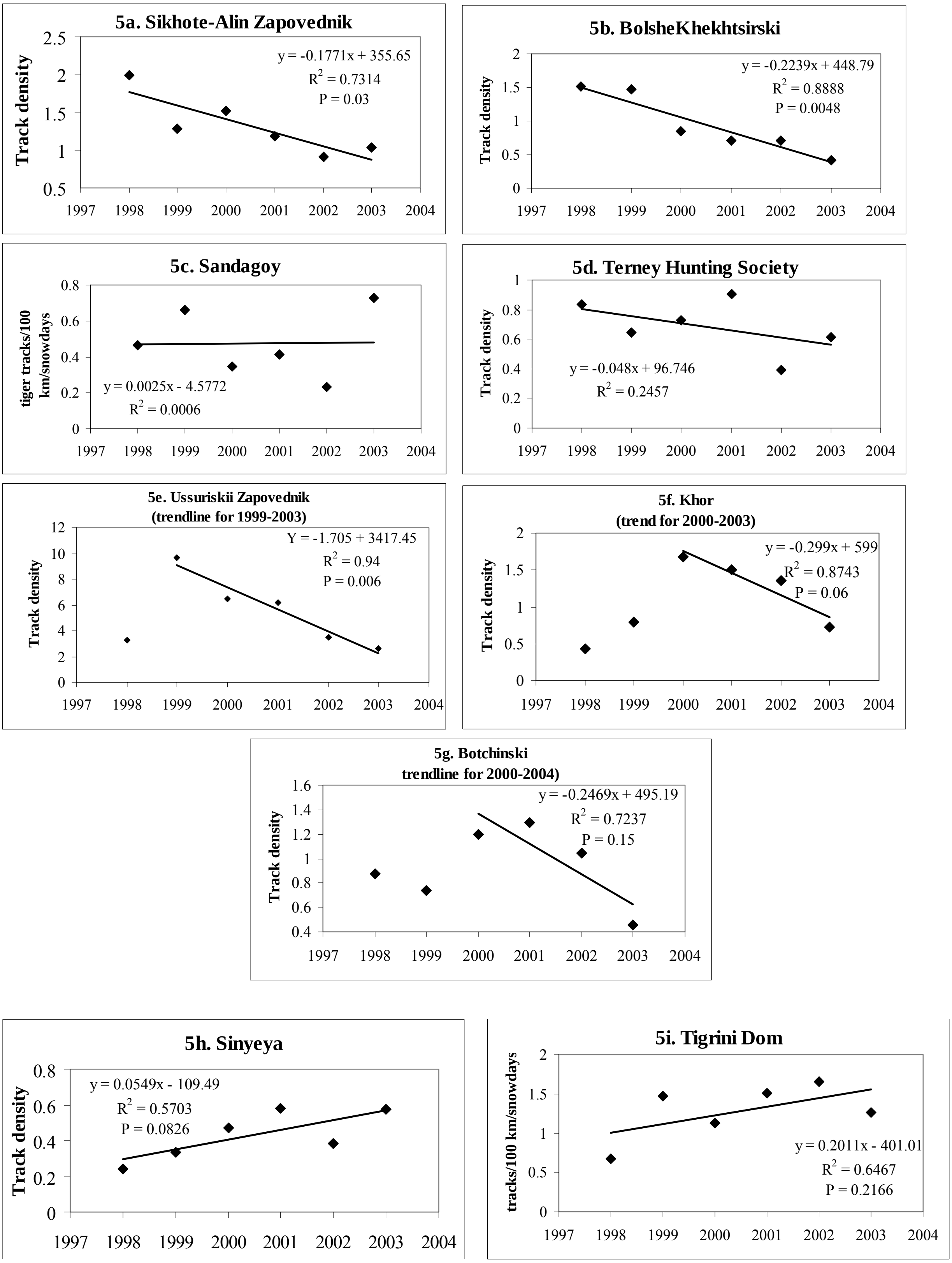


Figure 5a-i. Track density (tracks/100 km/days since last snow) and trends for 9 of the 16 sites of the Amur Tiger Monitoring Program which show trends (or change in trends) from 1998-2003, or over shorter periods of time.

We looked for trends in the tiger population using track data by applying a regression analysis to all 16 monitoring sites averaged for the year (Figure 4), but because differences in sites may be masked by averaging, we also pay attention to trends in individual sites (Figure 5). When looking at the overall regression for 6 years combined, no significant trend in track density was noted (r^2 = 0.29, F = 1.7, P = 0.26). However, because the initial rise between the first two years of monitoring dilutes the effect observed over the past 5 years. If we look at trends only over the past five years (deleting 1998 from the analysis) there is in fact a significant downward trend overall (r^2 = 0.81, F = 12.92, P = 0.04) (Figure 4).

Of the three sites that demonstrated significant downward trends from last year (2002) (using our criterion of P = 0.2), two continued to demonstrate drops in tiger track density (Sikhote-Alin and Bolshe-Khekhtsirski Zapovedniks, Figure 5a, 5b), while Sandagoy had a strong surge in track density (Figure 5c). Terney Hunting Society, which was also an area of concern last year, showed a slight increase in track density (Figure 5d). However, if we look at trends over the past 4-5 years (deleting year 1 – 1998 – which looks to be an unusual year, which may be related to the fact that it was the first year of the program, and methodologies were not yet adequately standardized), even more sites are showing downward trends. Specifically, Ussuriskii and Botchinski Zapovedniks, and the Khor monitoring sites (Figure 5e-g) also are showing downward trends in recent years that are significant (P = 0.06-0.14)). In contrast to at least 6 sites that appear to be showing downward trends in tiger track densities, only two (Sineya and Tigrini Dom) are demonstrating increases in track density (Figures 5h-i).

A comparison of trend lines for the two Krais suggests that the downward trend is more pronounced in Primorski than Khabarovsk Krai (Figure 6). Indeed, four of the six sites demonstrating downward trends in Figure 5 are in Primorski Krai.

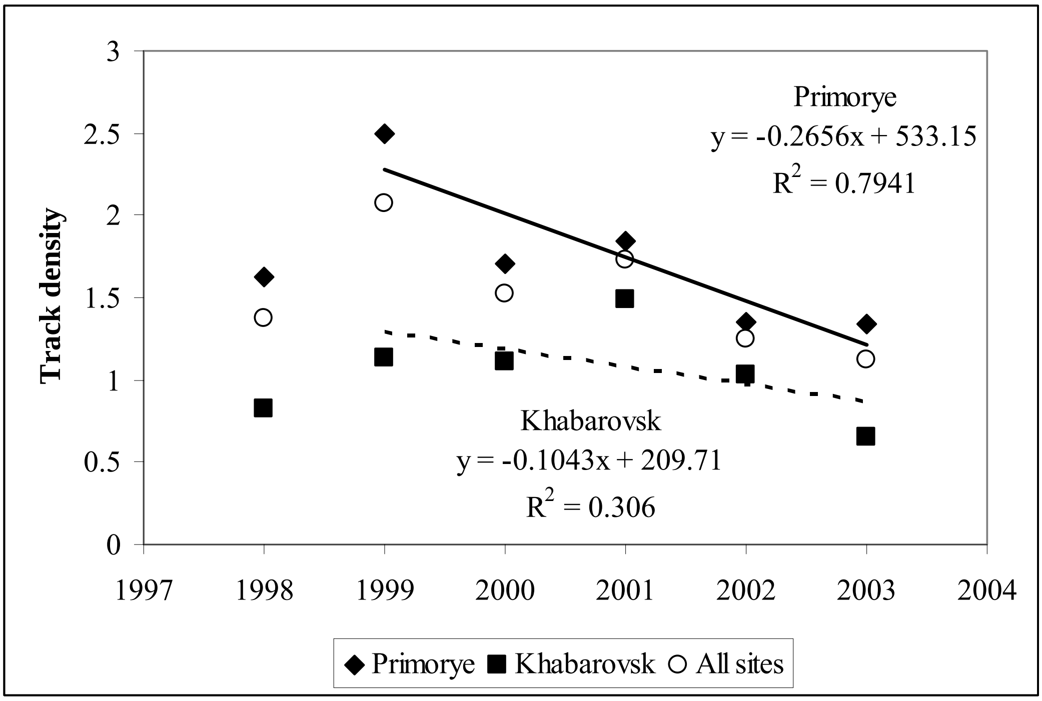


Figure 6. Comparison of trends for monitoring sites in Khabarovsk and Primorye, from 1999-2003.

Expert Assessment of Tiger Numbers on Monitoring Sites

Tiger densities, based on expert assessments, varied nearly over tenfold, from over 1.4 animal/100 km^2 in Ussuriski Zapovednik, to 0.13 /100 km^2 in Botchinski Zapovednik (Table 4). As with the other indicators (presence/absence and track density data), the three southern and central zapovedniks (Ussuriski, Lazovski, and Sikhote-Alin) contained some of the highest densities of tigers (all greater than 0.65/100 km^2), although density in Sikhote-Alin continues to drop (see below) (Table 4).

Although the track density data suggest a downward trend, the very slight downward trend observed in tiger density over the past 4 years was reversed this year (Figure 7). Considering the size of the 95% confidence intervals, overall the changes in tiger density, based on expert assessments, appear to be minimal over the past 4 years (Figure 7).

Although expert assessments of tiger densities appeared to be stable when averaged across all sites, many individual sites are showing a range of trends. Last year, only two sites – Sikhote-Alin and neighboring Terney Hunting Lease (for the past 4 years only), showed significant downward trends (negative slopes, high R^2 values, and $P < 0.2$). Those trends continued this year for both sites (Figure 8a-b), although Terney did show a slight increase in tiger density. An additional 2 sites also demonstrated downward trends this year: Bolshe-Khekhtsirski Zapovednik and Iman.

Last year two sites showed significant upward trends – Lazovski and Botchinski Zapovedniks. Those trends continued to be significant this year, but both were dampened by a decrease in density of independent tigers, based on expert assessments. Additionally, two more sites showed upward trends – Khor and Matai, both in Khabarovski Krai. Although the increase in the Khor is highly significant, 4 of the 6 years showed a stable tiger density; significance is due to a lower initial value in 1998, and a slightly higher value in 2003.

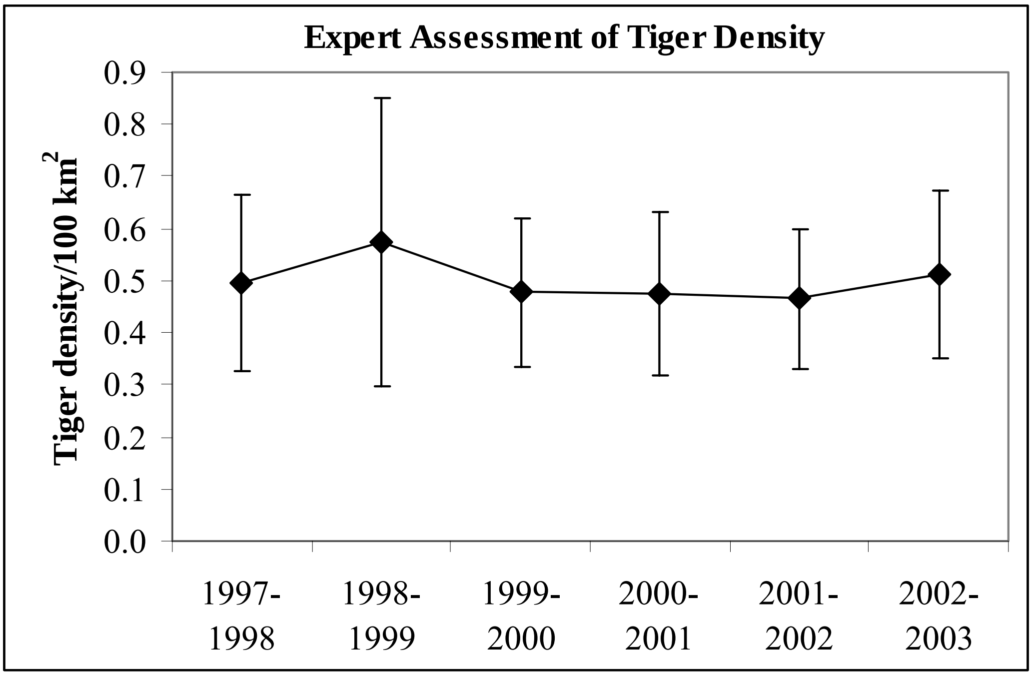


Figure 7. Trend in density of independent tigers (/100 km^2), based on expert assessments, for 16 sites in the Amur Tiger Monitoring Program, 1997-1998 through 2002-2003 winter seasons.

Table 4. Number and density 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, during the first six years of monitoring, 1997-1998 through 2002-2003.

Number of independent tigers	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	Average
Ussurisk Zapovednik	6	10	4	5	4	6	5,8
Bikin	3	10	7	6	7	8	6,8
Lazovski Zapovednik	6	9	10	11	12	9	9,5
Sandagoy	6	6	5	7	3	7	5,7
Sikhote Alin Zapovednik	21	21	23	17	17	16	19,2
Sineya	5	6	5	7	5	7	5,8
Lazovski Raion	8	4	5	4	6	5	5,3
Ussuriski Raion	6	1	2	2	9	6	4,3
Terney Hunting Lease	10	11	13	11	5	7	9,5
Khor	3	4	4	4	4	5	4,0
Borisovskoe Plateau	4	5	4	3	3	5	4,0
Tigrini Dom	4	6	4	4	5	6	4,8
Iman	8	6	5	6	6	4	5,8
Bolshekhekhtsirki Zapovednik	2	1	2	1	1	1	1,3
Mataiski Zakaznik	3	5	4	4	5	5	4,3
Botchinski Zapovednik	3	3	4	4	6	4	4,0
Density of independent tigers/100 km2							
Ussurisk Zapovednik	1,47	2,45	0,98	1,22	0,98	1,47	1,43
Bikin	0,29	0,97	0,68	0,58	0,68	0,78	0,67
Lazovski Zapovednik	0,50	0,75	0,84	0,92	1,01	0,75	0,80
Sandagoy	0,61	0,61	0,51	0,72	0,31	0,72	0,58
Sikhote Alin Zapovednik	0,88	0,88	0,97	0,72	0,72	0,67	0,81
Sineya	0,43	0,51	0,43	0,60	0,43	0,60	0,50
Lazovski Raion	0,81	0,41	0,51	0,41	0,61	0,51	0,54
Ussuriski Raion	0,42	0,07	0,14	0,14	0,64	0,42	0,31
Terney Hunting Lease	0,58	0,64	0,76	0,64	0,29	0,41	0,55
Khor	0,22	0,30	0,30	0,30	0,30	0,37	0,30
Borisovskoe Plateau	0,27	0,34	0,27	0,20	0,20	0,34	0,27
Tigrini Dom	0,19	0,29	0,19	0,19	0,24	0,29	0,23
Iman	0,57	0,43	0,36	0,43	0,43	0,29	0,42
Bolshekhekhtsirki Zapovednik	0,42	0,21	0,42	0,21	0,21	0,21	0,28
Mataiski Zakaznik	0,12	0,20	0,16	0,16	0,20	0,20	0,17
Botchinski Zapovednik	0,10	0,10	0,13	0,13	0,20	0,13	0,13

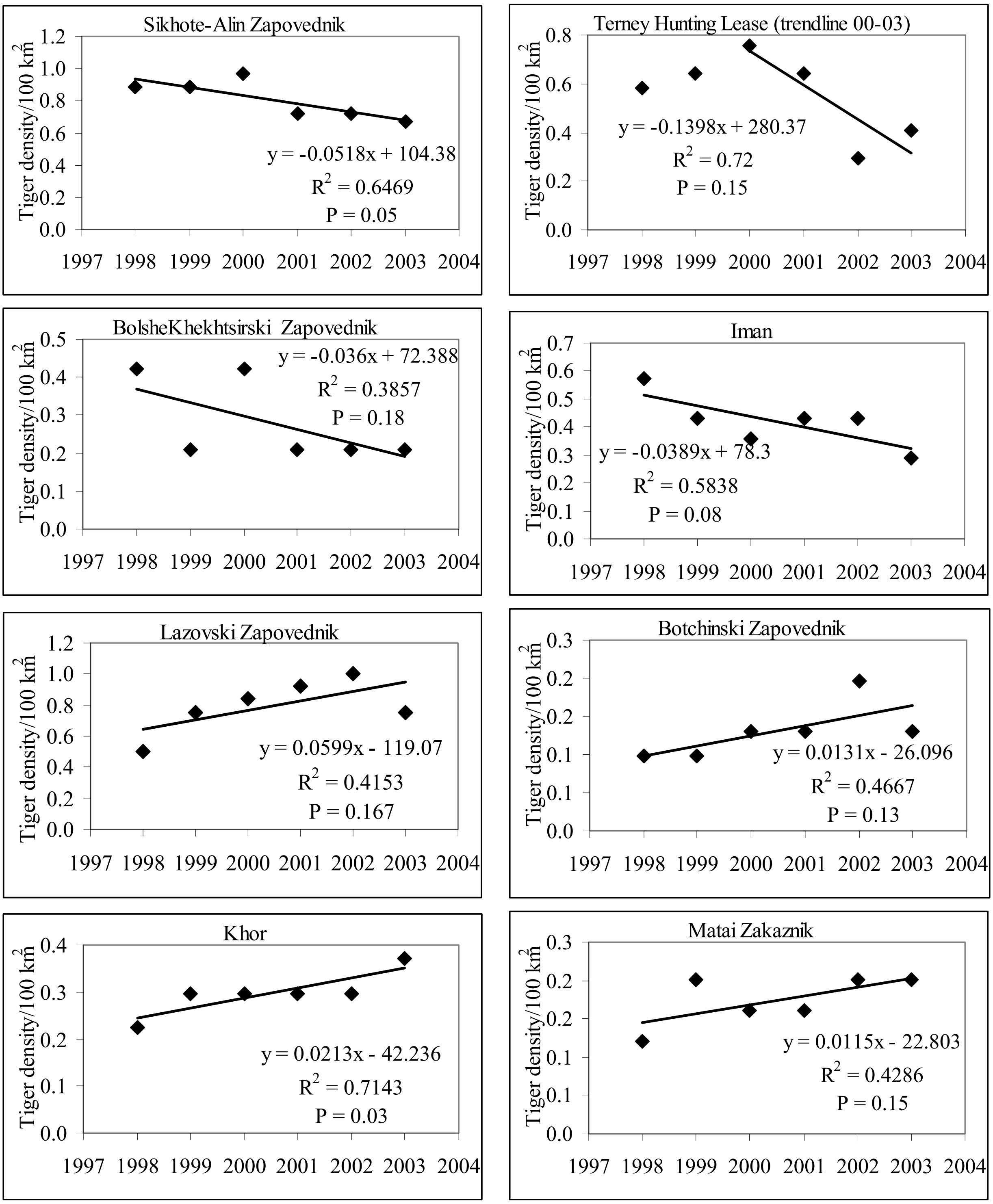


Figure 8a-h. Trend regression analyses for individual monitoring sites with P-values of a linear regression < 0.20 for changes in density of independent tigers across the six years of the monitoring program, winters 1997-1998 through 2002-2003.

Reproduction on Monitoring Sites

Expert assessments of tiger numbers and sex-age structure provide an opportunity to track changes in reproduction over time. As with last year, this year, we adjusted the number of litters in each monitoring unit to include tracks of cubs that were reported without adult females. These individuals may represent either young cubs temporarily without mothers, or cubs which have lost their mothers, but nonetheless they represent reproduction that has occurred on or partially on the monitoring units. Therefore, we have attempted to include such individuals (a total of 33 occurrences in the past 5 years) in our estimates for this year.

Since the 1997-1998 winter the number of litters reported on all sites combined has ranged from 11 to 26, with 13 litters reported for the 2002-2003 winter, compared to the 6-year average number of 16.6 litters per year. The number of cubs reported for this year (23) was very close to the 6-year average (23.8) (Table 5, Figure 9). The percentage of units without cubs has ranged from 18.7 to 56.7%, with this past winter (2002-2003) representing the highest value reported yet. In general, these values suggest that overall reproduction across the range was moderate to good for the 2001-2002 winter season.

Over the five years of monitoring, cub production has been recorded in each of the 16 monitoring sites at least once (Table 5), but only one site, Ussuriski Zapovednik has reported reproduction in each of those 6 years. Six sites - Sikhote-Alin Zapovednik, Terney Hunting lease, Lazovski Zapovednik, Lazovski Raion, Borisovkoe Plateau, and Mataiski Zakaznik – have reported cubs in 5 of 6 years. Reproduction therefore appears most likely on zapovedniks, or territories adjacent to zapovedniks (5 of the 7 sites listed above fall into this category.

An unusual situation is developing in regards to tiger reproduction on monitoring sites. There is a relatively strong trend towards increasing numbers of sites without cubs each year (Figure 11), yet overall cub production has remained stable (Figure 9). Stability in cub production appears to be due to the fact that, although numbers of females with cubs is decreasing, mean litter size is increasing (Figure 12, Table 6). In 2003 four litters of three cubs were reported, the most by far of all 6 years. Ultimately, these results indicate a precarious situation developing, where reproduction is being more and more concentrated in a few key areas.

Table 5. Number of litters, and number of cubs produced on each monitoring unit for 5 winters, 1997-1998 through 2002-2003, based on expert assessments of tiger tracks for the Amur Tiger Monitoring Program.

	Litter production							Cub production						
	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	Total litter production	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	Total cub production
Lazovski Zapovednik	1	1		2	2	3	9	2	2		5	4	7	20
Lazovski Raion	3	2		1	4	1	11	3	3		3	7	1	17
Ussurisk Zapovednik	3	4	1	1	2	1	12	4	4	3	2	4	3	20
Iman		2	1	1	1		5		3	2	2	1		8
Bikin	3		1		1	2	7	3		1		2	2	8
Borisovskoe Plateau	2	1	1	1		1	6	2	1	1	1		2	7
Sandagoy	3	1			1		5	4	1			2		7
Khor	1	1			1		3	1	1			1		3
Botchinski Zapovednik	1		2	1			4	1		2	2			5
Bolshekhekhtsirki Zapovednik		1					1		1					1
Tigrini Dom		1	1	1	2		5		1	1	1	2		5
Mataiski Zakaznik	3	2	1		1	2	9	4	2	2		1	4	13
Ussuriski Raion		1					1		2					2
Sikhote Alin Zapovednik	4	3	2	2		3	14	4	4	2	3		4	17
Sineya	1				1		2	1				3		4
Terney Hunting Lease	1	2	1	1	1		6	1	2	1	1	1		6
Totals	26	22	11	11	17	13	100	30	27	15	20	28	23	143

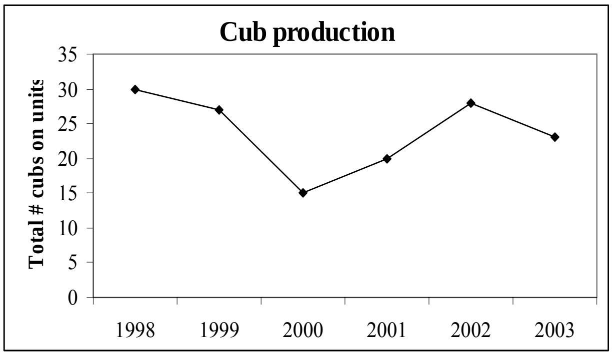


Figure 9. Total cub production for the 6 winter seasons, 1997-1998 through 2002-2003, on all 16 units combined for the Amur Tiger Monitoring Program.

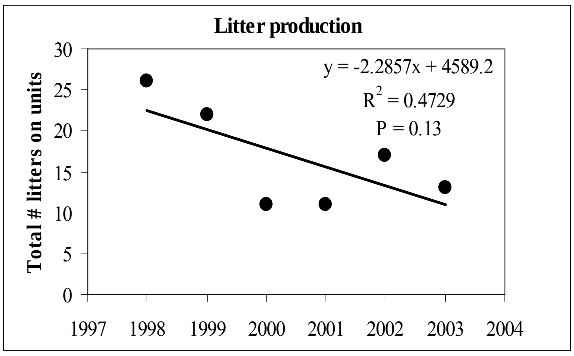


Figure 10. Litter production (total number of litters produced) on all 16 units combined for the Amur Tiger Monitoring Program appears to be decreasing.

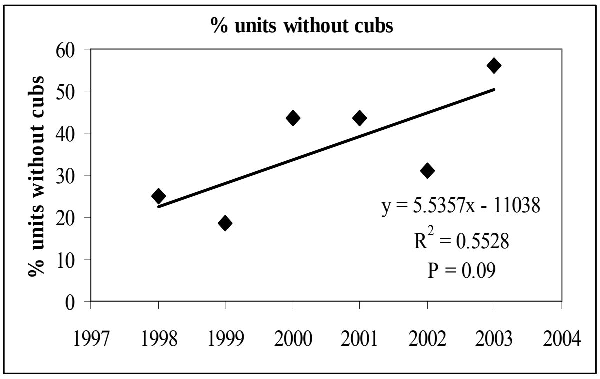


Figure 11. Percent of sites without cubs appears to be increasing over time in the Amur Tiger Monitoring Program, based on 6 years of monitoring, winter 1997-1998 through 2002-2003.

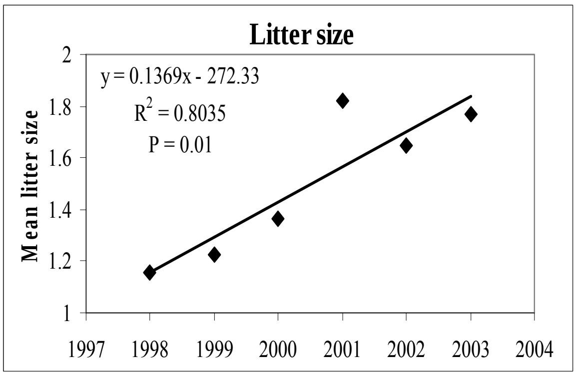


Figure 12. Increase in the mean litter size over time is maintaining overall stable cub production across the 16 Amur tiger Monitoring units, even though total litter production is decreasing and number of units without cubs is increasing.

Because most of the reproduction is occurring in or near zapovedniks, these results suggest that conditions may be deteriorating in units outside protected areas. Analyses of the existing data on productivity only partly support this hypothesis. Litter production has decreased in both unprotected and protected areas (zapovedniks and adjacent monitoring units) (Figure 13), but nonetheless cub production remained at high levels through most years in zapovedniks and adjacent territories, while cub production has dropped in unprotected territories (Figure 14). Therefore, it appears that litter production has dropped across all units, but it is only in the protected areas that litter size has increased. The cause for an increase in litter size is not all clear, but raises a number of interesting questions.

Table 6. Litter size of all litters recorded in 6 winters of the Amur Tiger Monitoring Program, based on expert assessment of tracks				
	Litter size			
Year	1	2	3	Total
1997-1998	23	4	0	27
1998-1999	17	5		22
1999-2000	8	2	1	11
2000-2001	4	5	2	11
2001-2002	8	7	2	17
2002-2003	7	2	4	13
Total	67	25	9	101

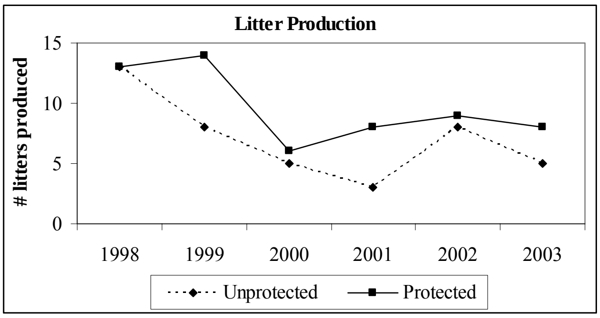


Figure 13. Litter production in unprotected monitoring units, and in zapovedniks and adjacent monitoring units (n=8 units for both categories).

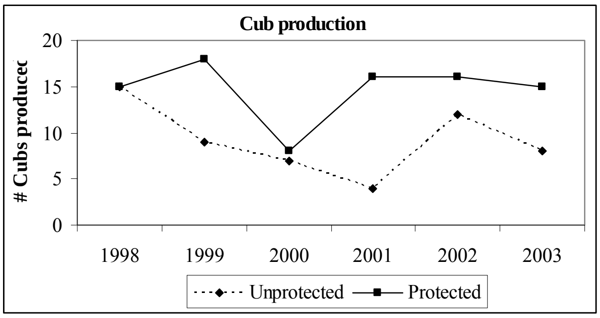


Figure 14. Cub production in unprotected monitoring units, and in zapovedniks and adjacent monitoring units (n=8 units for both categories).

Ungulate Populations on Monitoring Sites

As in previous years, prey numbers varied greatly among sites (Table 7). To attempt to understand how density estimates varied across monitoring sites and time, we conducted a regression analysis to look for trends across time (6 years of monitoring), looking first at trends for all sites combined, and then separately for each site and each species. We report all sites where the probability is less than 0.2 that the slope is not zero, under the understanding that firstly, that we are looking for general trends and potential early warning signs across the region and within each monitoring site. Many of the details of ungulate densities are provided in the individual accounts of each site (Part II). We report results there separately for each species.

Red deer. As in past years, track count densities of red deer were highest in Bolshe-Khekhtsirski Zapovednik, and secondly, in Sikhote-Alin Zapovednik (Table 7). While one might expect red deer density to decrease with increasing latitude, in fact this was not the cast (Figure 15). Red deer reach their highest densities in the central portion of their range in the Russian Far East, and their lowest densities in the south where competition (or disease?) with sika deer appears to be decreasing their densities (Figure 15): in Borisovskoe Plateau red deer no longer occur (Table 7), although 30 years ago they were considered the most abundant ungulate in the area (Pikunov, pers. comm.).

There was no significant trend in red deer numbers over the six years for all sites combined (Figure 16), although it appears that the track density index returned to the 2001 level after a sharp decrease in 2002.

Table 7. Mean track density/10 km of transect, and 95% confidence intervals on 16 units of the Amur Tiger Monitoring Program, for the 2002-2003 winter.

		Red deer		Wild boar		Roe deer		Sika deer	
Monitoring Unit	N	mean	95% ci	mean	95% ci	mean	95% ci	mean	95% ci
Lazovski Zapovednik	12	1.14	1.19	7.82	7.19	0.62	0.71	42.71	25.57
Lazovski Raion	11	0.36	0.71	1.99	1.69	0.10	0.13	28.96	19.42
Ussurisk Zapovednik	11	4.66	2.39	0.99	0.85	2.18	1.56	11.18	7.36
Iman	12	6.35	3.81	1.21	0.80	6.83	4.66	0	
Bikin	16	10.29	5.31	3.08	2.51	3.41	1.36	0	
Borisovskoe Plateau	14	0.00		6.64	3.83	2.69	1.42	18.58	13.49
Sandagoy	16	6.87	3.61	2.42	1.18	6.39	4.81	2.86	2.04
Khor	19	13.28	4.96	2.33	1.52	5.01	3.77	0	
Botchinski Zapovednik	14	5.26	1.38	0.00		6.44	2.74	0	
Bolshekhekhtsirki Zapovednik	7	36.57	21.68	28.82	31.45	0.68	0.92	0	
Tigrini Dom	14	2.39	1.13	0.14	0.16	0.09	0.09	0	
Mataiski Zakaznik	24	9.63	2.57	5.77	1.66	4.11	1.84	0	
Ussuriski Raion	12	2.72	1.85	1.19	0.94	1.90	1.05	0.96	0.97
Sikhote Alin Zapovednik	25	25.65	6.83	2.16	1.07	21.75	7.94	15.85	13.67
Sineya	15	2.25	0.85	0.86	0.67	5.40	1.62	0	
Terney Hunting Lease	24	10.32	6.18	0.40	0.35	11.08	6.11	2.68	3.30
Average*	246	9.18		4.11		4.92		15.474	

*average estimated only for units where species was present.

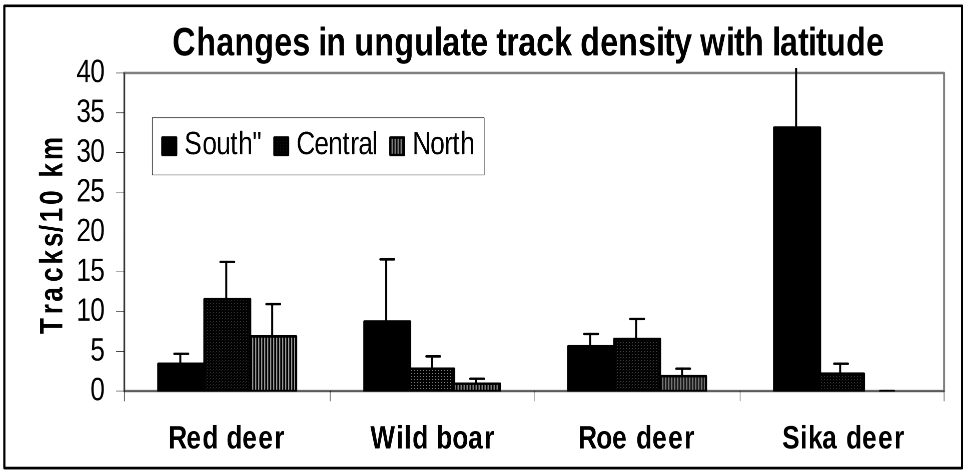


Figure 15. Changes in ungulate track density (fresh tracks/10 km of routes) with changes in latitude, with each monitoring site categorized as southern, central, or northern (see Table 1 in Section I). The average track density for each site for each year considered a sampling unit (n = 64).

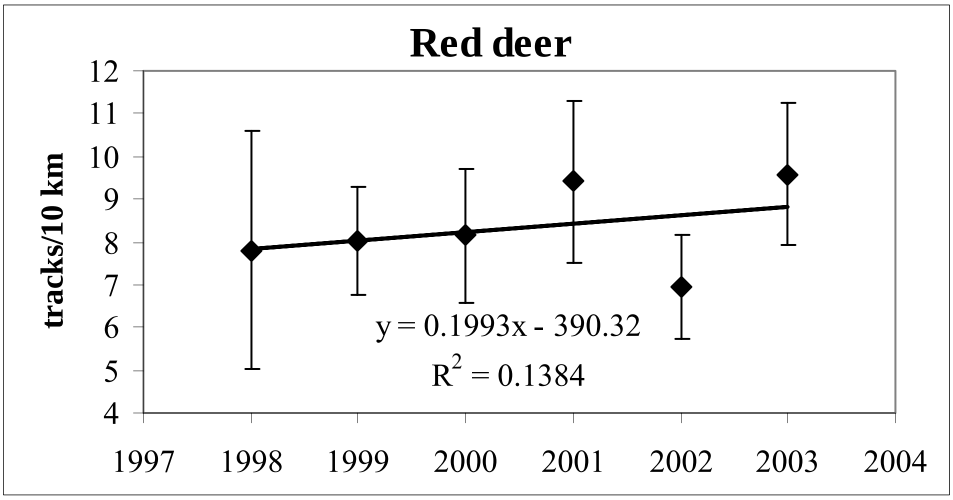


Figure 16. Average red deer track density and 95% confidence intervals for all sites except Borisovkoe Plateau (where red deer are absent) for the first six years of the Amur Tiger Monitoring Program, 1997-1998 though 2002-2003.

However, the pattern of trends within monitoring sites is complicated, with 4 sites showing negative trends, and 4 sites showing positive trends (Figure 17). There were three monitoring sites (Lazovski Zapovednik, Sandagoy, and Bolshe-Khekhtsirski Zapovednik) where red deer numbers may be increasing (Figure 20) , but that trend was statistically significant only for Lazovski Zapovednik (r^2 = 0.904, P = 0.049). There appears to be no consistent pattern as to which sites are showing which trends (e.g. northern versus southern, etc.) and therefore at this point all we can say is that it appears that local conditions have a large effect on red deer population trends, and while overall across the region there appears no clear trend, populations are changing at a finer scale of resolution.

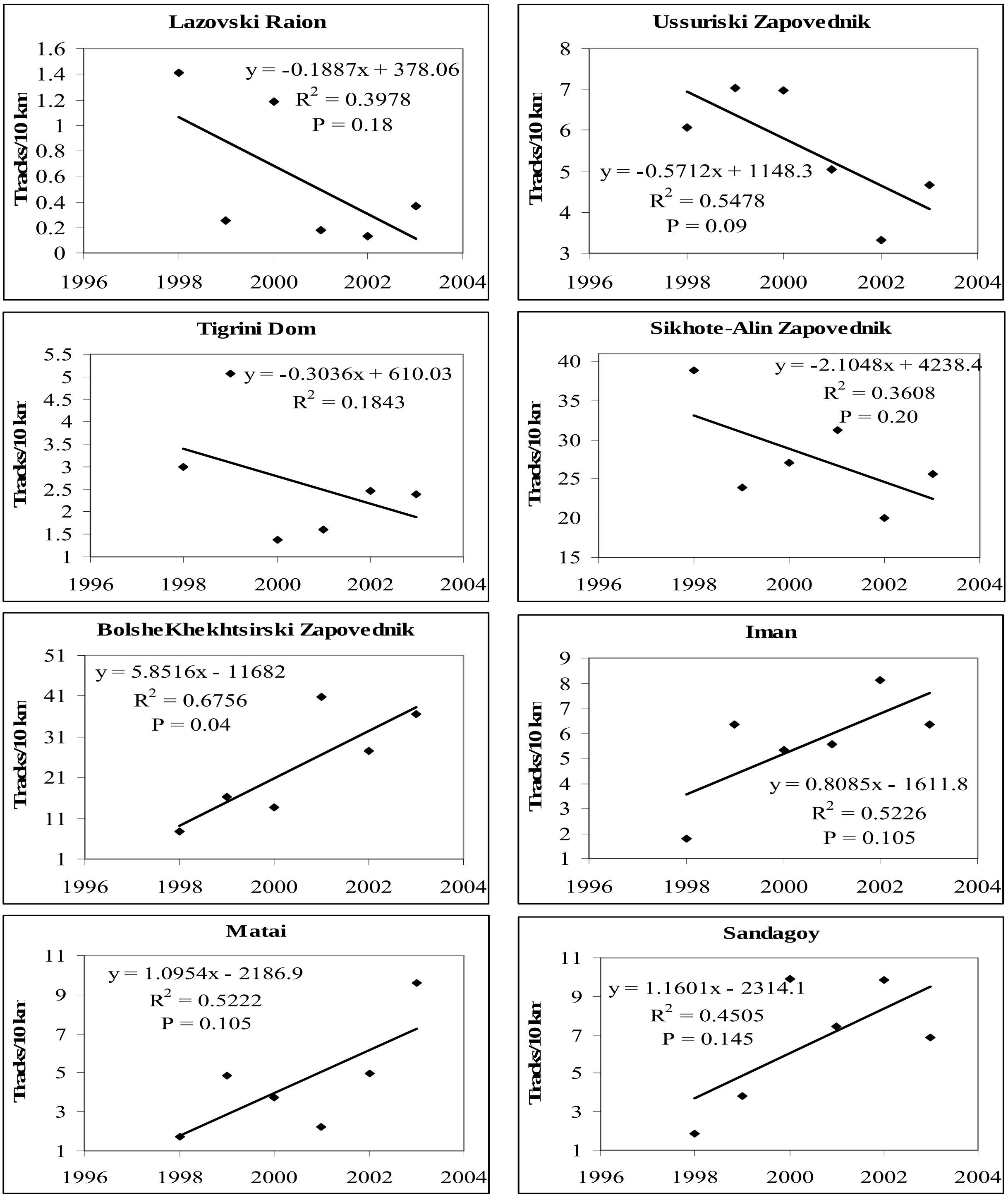


Figure 17. Changes in red deer densities, as measured by fresh tracks/10 km along routes in 8 of the 16 monitoring sites of the Amur Tiger Monitoring Program.

Wild boar. Wild boar populations are known to fluctuate more dramatically than deer populations, and because they are commonly found in groups, are more problematic to accurately estimate density. Nonetheless, overall track density of wild boar has remained relatively steady, with the possible exception of the first year of monitoring (Figure 18).

Wild boar densities varied amongst sites greatly, from 28 tracks/10 km in Bolshe-Khekhtsirski Zapovednik to 0 encounters in Botchinski Zapovednik. Despite the apparent overall stability, as with red deer, wild boar in half of the monitoring sites appear to be undergoing increasing or decreasing trends (Figure 19), with 4 each demonstrating increases and decreases. Sikhote-Alin Zapovednik and neighboring Terney Hunting Lease both demonstrated significant ($P < 0.2$) trends, suggesting that a real decrease may be ongoing for that general area. Similarly, Ussuriski Raion and Ussuriski Zapovednik are showing downward trends (non-significant for the Zapovednik, but of a similar magnitude). On the other hand, both Lazovski Raion and Lazovski Zapovednik are showing an increase in track densities, suggesting that wild boar may be increasing in that general area. While Matai and neighboring Khor units are also showing increases in Khabarovski Krai, slightly to the north wild boar appear to be decreasing in Tigrini Dom.

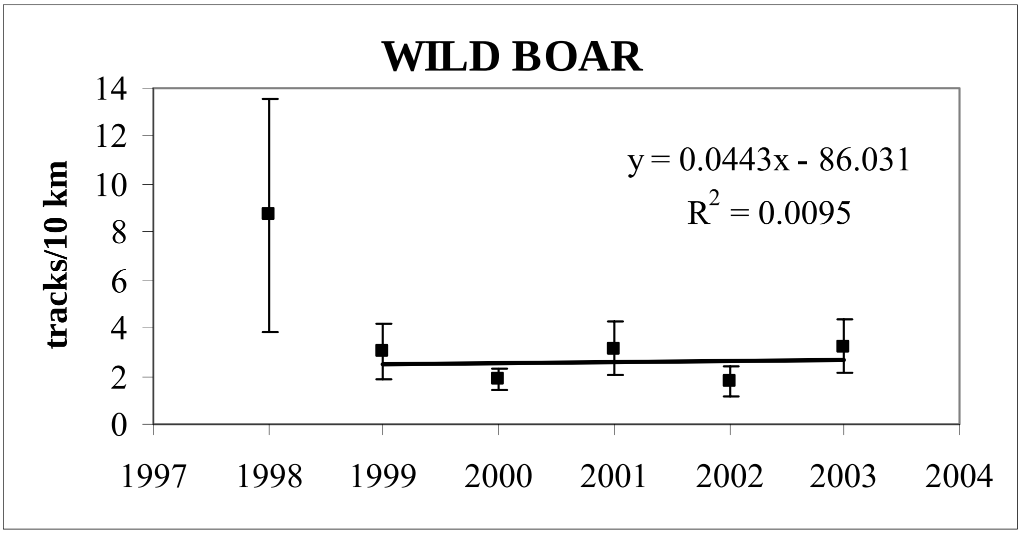


Figure 18. Average wild boar track density and 95% confidence intervals for all sites, for each of the first six years of the Amur Tiger Monitoring Program, 1997-1998 though 2002-2003.

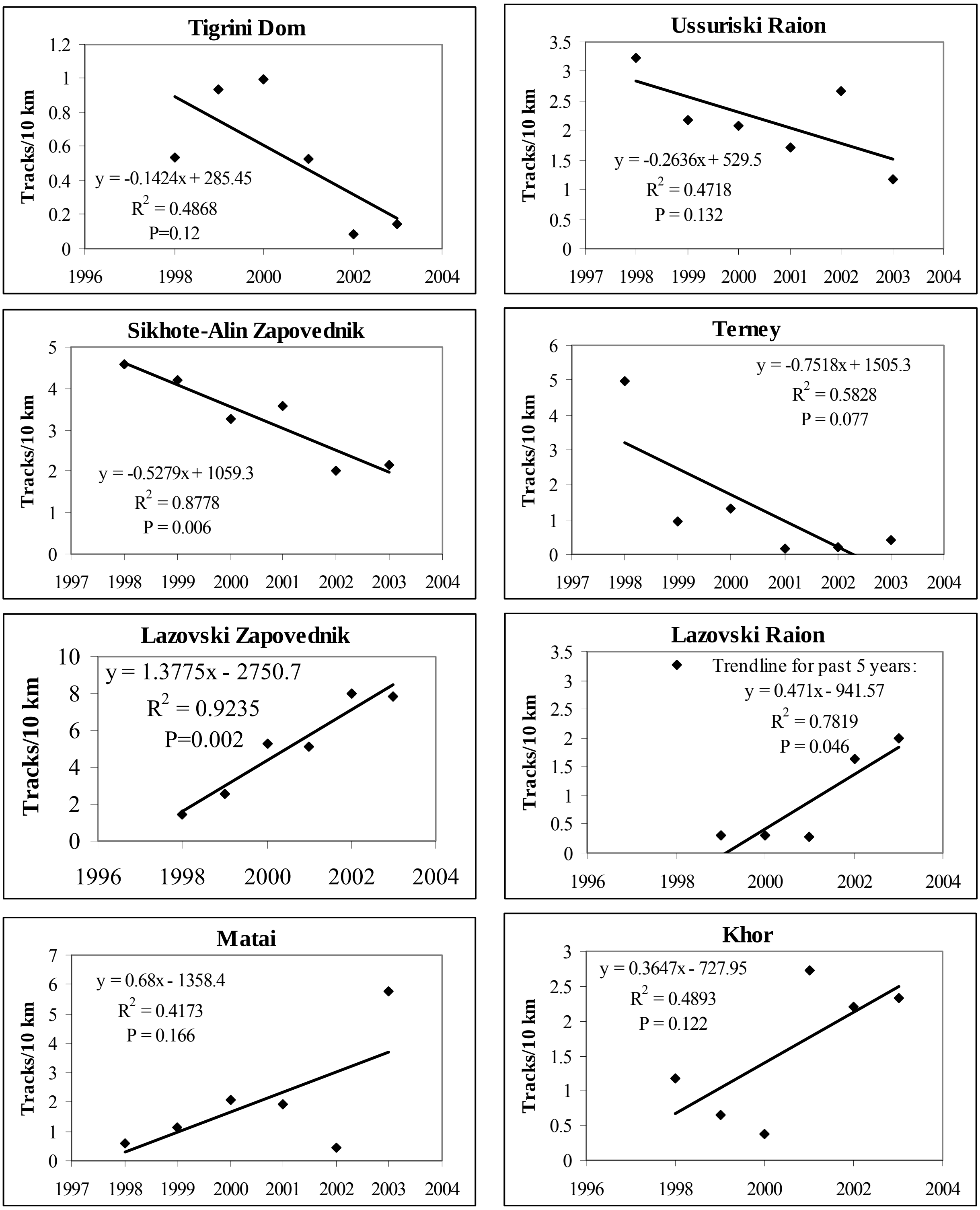


Figure 19. Changes in wild boar densities, as measured by fresh tracks/10 km along routes in 8 of the 16 monitoring sites of the Amur Tiger Monitoring Program where the probability is less than 0.2 that the slope of the line does not equal zero.

Sika deer. Sika deer occur regularly in only eight of the monitoring units, including all 6 in the south, and 2 of the central monitoring sites (Table 7). However, in the two central units where they occur (Sikhote-Alin Zapovednik and Terney Hunting Lease) they exist in localized pockets, and are not distributed throughout the monitoring units. Therefore, for the purposes of this analysis, we have deleted them. However, sika deer appear to be increasing in the coastal areas of Terney Raion, and we expect them to become a more important prey item in the diet of tigers there in the future.

Track densities (and presumably animal densities) are generally much higher for sika deer than other ungulate species (Figure 15). Of the six southern sites, only in Ussuriski Raion are track densities low (less than 3 tracks/10 km). Highest track densities have been recorded in Boriskovkoe Plateau (in 1998) but sika deer are highly gregarious, and there is great variation in track counts dependent on the number of groups encountered along transects. Greater sampled is probably required to obtain more accurate estimates of track densities, with smaller confidence intervals. No significant trends appear across the 6 southern sites if all six years are considered, but over the past 4 years, despite large confidence intervals for 3 of those 4 years, there does appear to be a downward trend in track densities of sika deer (Figure 20).

Evidence for this downward trend over the past 4 years is found at all six southern sites (Figure 21). Track indices have been decreasing in Borisovkoe Plateau for all 6 years of monitoring. Highly significant downward trends ($P < 0.05$) over the past four years exist in Lazovski Zapovednik, Ussuriski Zapovednik, and Ussuriski Raion (Figure 21). Lazovski Raion, and Sandagoy have non-significant, but downward trends. The overall results strongly suggest that sika deer numbers are falling across southern Primorye, and should be a cause for concern.

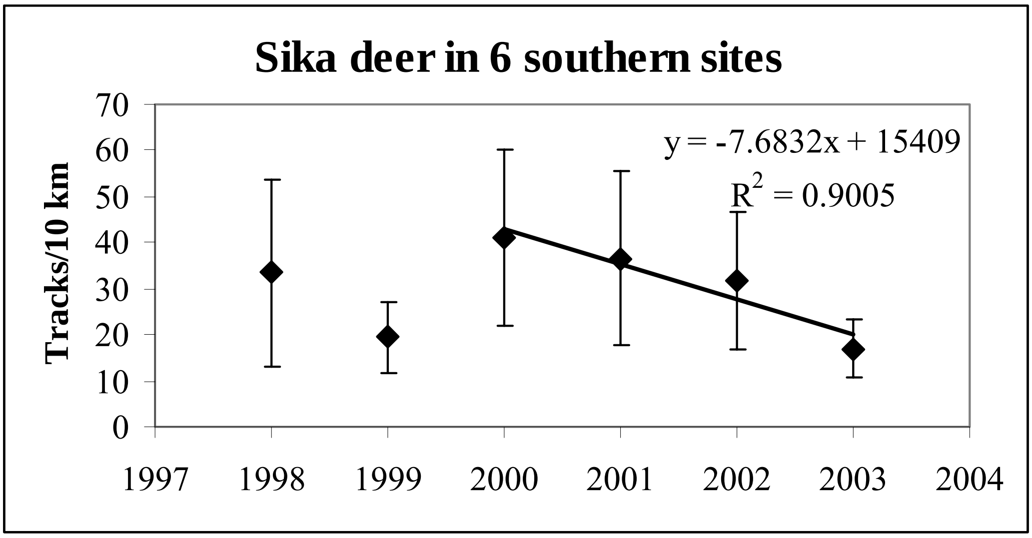


Figure 20. Average sika deer track density and 95% confidence intervals for all sites, for each of the first six years of the Amur Tiger Monitoring Program, 1997-1998 though 2002-2003, and trend line for the last 4 years..

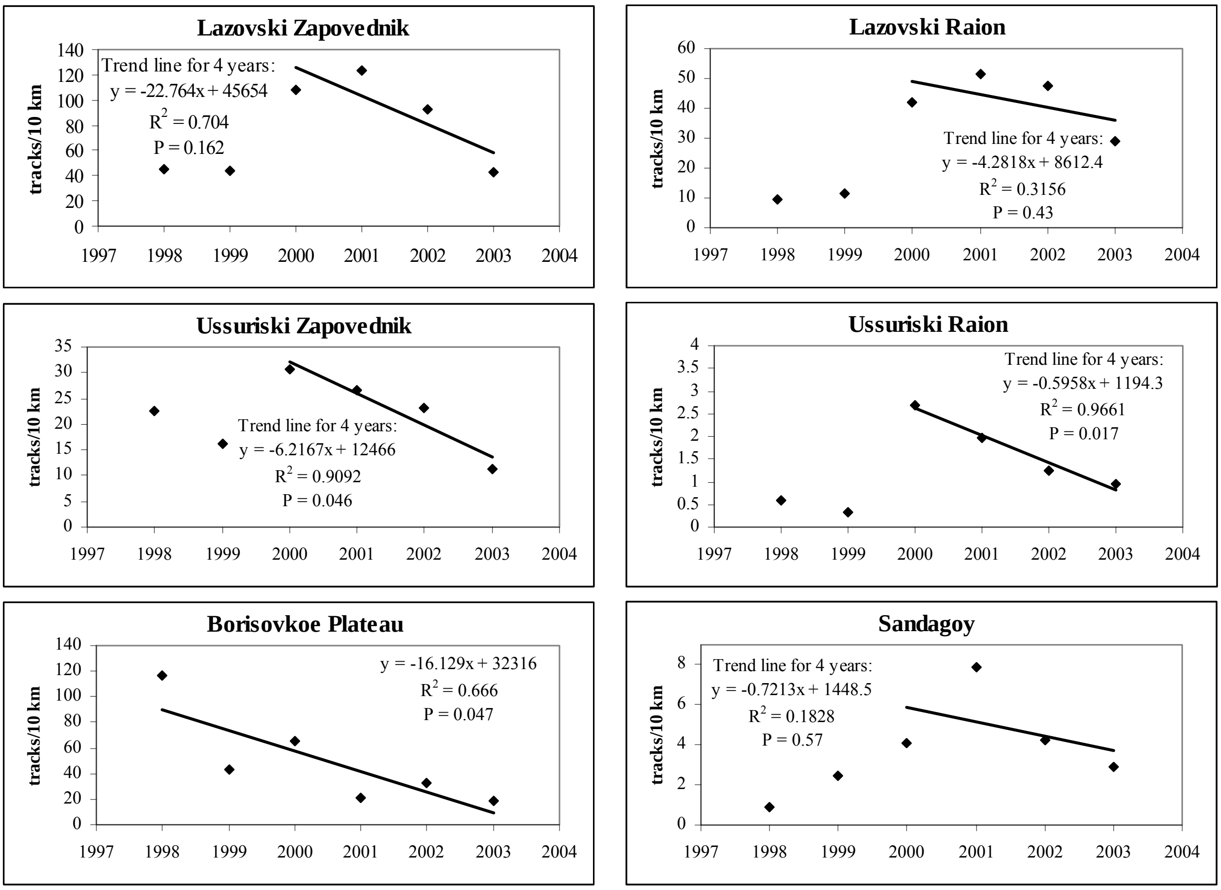


Figure 21. Changes in sika deer densities, as measured by tracks/10 km along routes in the 6 southern monitoring sites where this species occurs in the Amur Tiger Monitoring Program (Sikhote-Alin Zapovednik and Terney Hunting Lease, where this species is spottily distributed at the northern edge of its range, are not included here).

Roe deer. As with wild boar, roe deer are found on all 16 monitoring sites, but track abundance indices range from 0.09 tracks/10 km in the northern site of Tigrini Dom, to a high of 21.75 in Sikhote-Alin Zapovednik. Although roe deer are not a primary prey species of tigers, information on trends on roe deer do provide an index of habitat quality for tigers, and may reflect other changes ongoing in the region (e.g. poaching pressures, changes in habitat quality).

Estimates of roe deer density have been the most stable of all ungulate species. Although there has been no statistically significant change in roe deer track densities across all 6 years of monitoring, there has been a significant increasing trend in track densities from 5.0 tracks/10 km in 1998 to 6.1 tracks/10 km in 2003 (Figure 22).

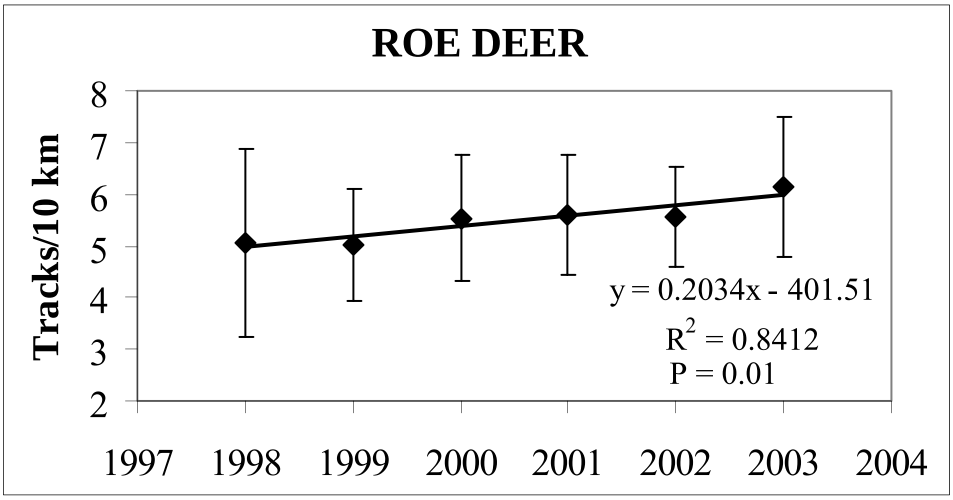


Figure 22. Average roe deer track density for all sites, for the first six years of the Amur Tiger Monitoring Program, 1997-1998 though 2002-2003.

As with red deer, roe deer densities peak in the central monitoring sites highest (Table 7). Despite the overall positive trend, different sites demonstrate varying trends. Four sites demonstrated trends that suggest a decrease in roe deer is occurring, while four sites also demonstrated a positive trend (Figure 23). Three of the sites with decreasing trends are in the south, but those sites with increasing track indices of roe deer represent a mixture of southern, central, and northern sites (Figure 23), suggesting that extrapolation to regional tendencies is inappropriate in this case. However, the fact that both Ussuriski Zapovednik and Ussuriski Raion demonstrate decreases in roe deer track indices is a strong indication that roe deer numbers are indeed decreasing in this general region.

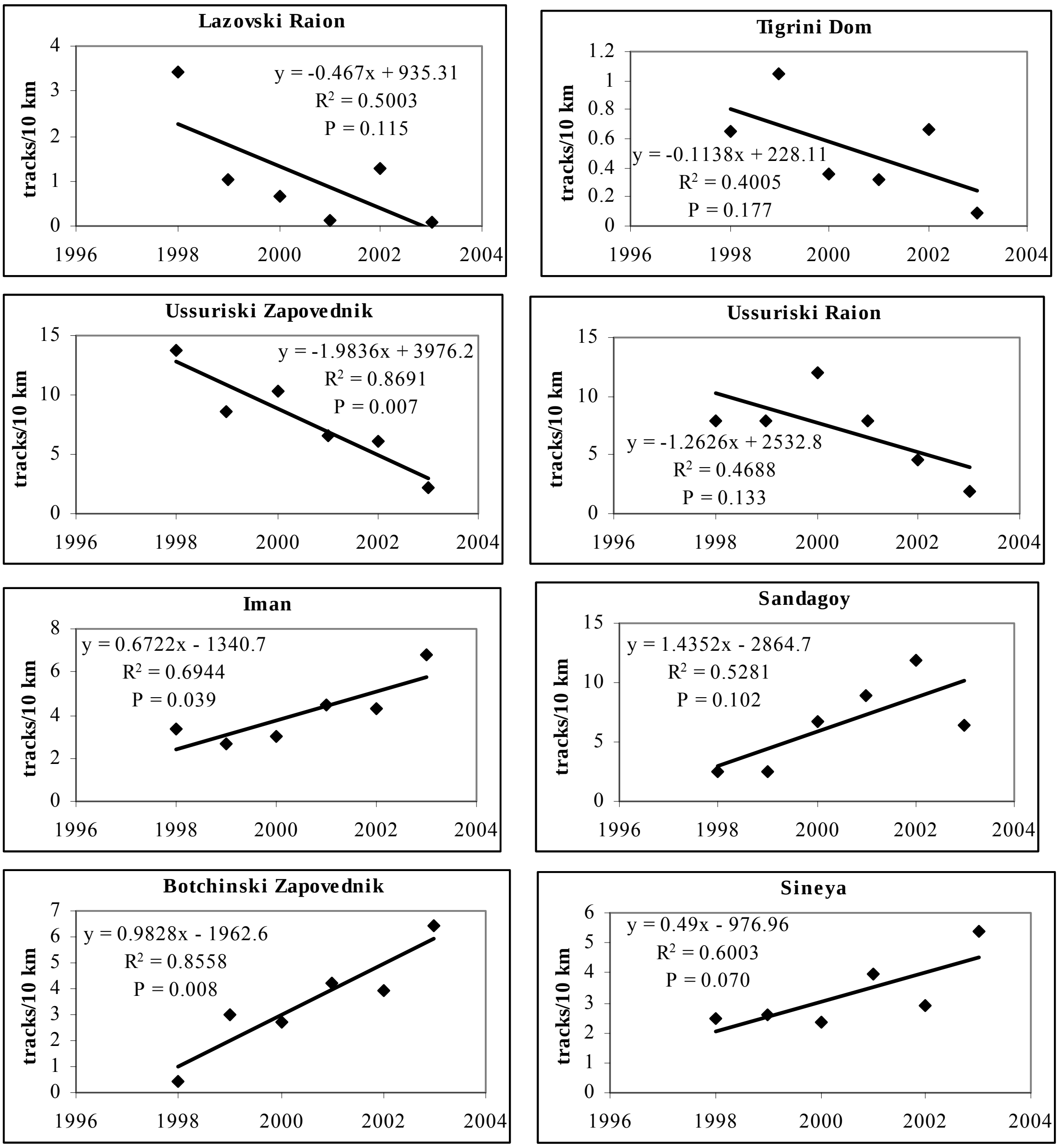


Figure 23. Trends in roe deer densities, 1997-1998 through 2002-2003, as measured by fresh tracks/10 km along routes in 8 monitoring sites (where $P < 0.2$ that the slope of the line does not equal zero) of the Amur Tiger Monitoring Program.

Trends in the Amur Tiger Population and a Scorecard for Monitoring Sites

We used a linear regression trend analysis for the three indicators of tiger abundance: % routes with tigers present, mean track density, and an expert assessment of independent tiger density. The intent of these regression analyses is to identify trends in the tiger population across the whole region, and in each of the monitoring sites. The actual relationship of true tiger density to any of these three indicators is unknown, but is assumed to be real, and therefore we seek patterns in all three indicators to determine trends in the overall tiger population.

Last year was the first year that all three indicators suggested that a decrease in tiger numbers was underway. This past winter, two of the indicators (presence of tracks, and expert assessment of tiger numbers) showed slight increases, eliminating any statistically significant trends in those indicators. Track density, however, continued to decline. While the tiger numbers derived by expert assessments appear to be quite stable, the other two indicators show considerable fluctuations. Although the results from the 2002-2003 slightly relieve concerns about a decreasing tiger population, many of the individual sites still appear to be areas of grave concern.

Cub production continues to be an area of concern. Although the total number of cubs produced this year on all sites combined (23) is almost exactly at the 6-year average (23.8), the number of litters being produced continues to decline (Figure 10). Total cub production remains stable because litter size appears to be increasing. The reason for this increase in litter size is not clear, but the results indicate that fewer and fewer monitoring sites are producing cubs; 61% of the cubs reported over the 6 years of monitoring have been produced on 5 sites (31% of sites), and there is a trend towards fewer and fewer sites producing cubs (Figure 11). Further increases in litter size are unlikely, and therefore continued decline in cub production on many sites suggests that recruitment in the future may not be able to compensate for total mortality, in which case we would anticipate a further decline in tiger numbers.

We have defined sites as "areas for concern" if the trend analyses demonstrates a negative slope for which the statistical probability was greater than 80% (i.e. $P < 0.2$) that the population was not stable (i.e. that the slope of the line did not equal zero). We have used the same criteria for defining sites as "areas with positive growth indicators" if the slope is positive.

This is a very conservative approach, as most statisticians use a P value of 0.05. By increasing the P value to 0.2, we dramatically increase the probability of defining a site as an "area of concern" or an "area of positive growth indicators" when in fact such may not be the case. Our rationale for taking this approach is that we must have a mechanism for identifying areas early, so that remedial action can take place: a more liberal approach (with a smaller P value) would result in fewer "false alarms" but may not identify all areas in time to respond on an appropriate time scale.

To balance this conservative approach, we have developed a weighted "scorecard" to rank monitoring sites based on a suite of indicators. We have given a plus or minus to each site if the trend analysis for that indicator was significantly positive or minus (at $P = 0.2$), and then given each a weighted value based on its importance in determining the status of tigers on that site. The three indicators of tiger abundance (presence on transects, track density, and expert assessments) are given equal value weighting of +3 (positive trend) or -3 (negative trend). Significant trends in red deer, wild boar, and sika deer abundance indices are given a weight value of +2 (positive) and -2 (negative trend). Changes in roe deer, a less important prey species, are given a weight of 1. Cub production on each site was weighted +3 if there had been cubs in each of the past four years; if cubs were present 3 of past 4 years, a weight of 2 was given; if cubs were present in only 2 of the past four years, a 0 value was given; if cubs were present for only 1 of 4 years, a value of -2 was given, and if cubs were not present in any year, a value of -3 was given (Table 8). Thus, a monitoring site for which all indicators were steady, and for which reproduction was reported in all of the past four years, would score +3. The maximum positive score (with all tiger indicators increasing, all prey increasing, and reproduction occurring in all four years) would be 19, and similarly the worse-case scenario with all trends decreasing without reproduction, a site would score -19. We emphasize that this scorecard represents an indication primarily of trends - of tiger numbers and factors that directly relate to tiger numbers - and not to present tiger density per se. The intent here is to identify areas where conditions are changing so that potential interventions can be initiated, as well as to identify areas where things appear to be improving.

Based on this set of scoring criteria, the monitoring site that appears to improving most is Matai Zakaznik. One index of tiger abundance suggested that numbers were increasing in Matai, both red deer and wild boar indices suggest numbers are increasing, and tiger reproduction occurred in 2 of the past 4 years (Table 9). The majority of sites (10) appear to be stable, with scores ranging from 0 to 4 (Table 9). However, these "average" scores can mask changing internal dynamics of a site. For instance, in Tigrini Dom two indicators of tiger abundance suggest an increase, but 3 prey species appear to be declining, suggesting an imbalance developing between prey numbers and predator. If this situation continues, we would expect to see declines in tiger numbers in Tigrini Dom in the near future. Similarly, in Lazovski Zapovednik, the expert assessment suggests tiger numbers are increasing, but 3 of 4 prey species are decreasing. While decreases in red deer may represent an overall regional trend in southern Primorye, the simultaneous decrease in sika deer could have serious repercussions for tiger numbers there.

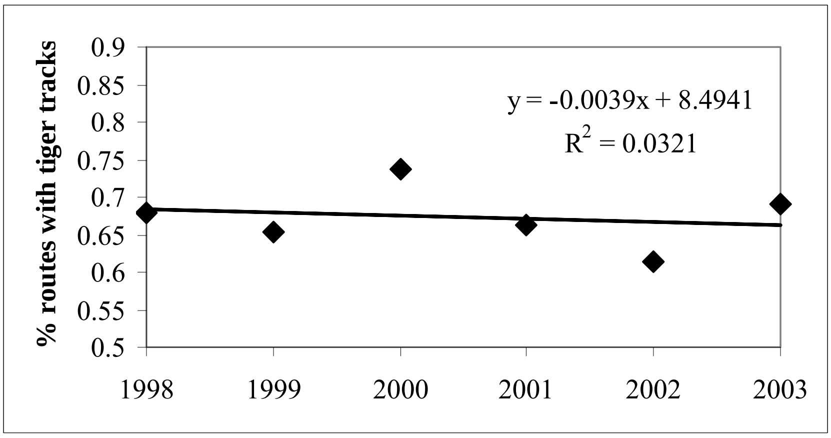


Figure 24. Overall trends in presence of tiger tracks on routes, averaged for all 16 sites of the Amur Tiger Monitoring Program, from the 1997-1998 winter through 2002-2003 winter season.

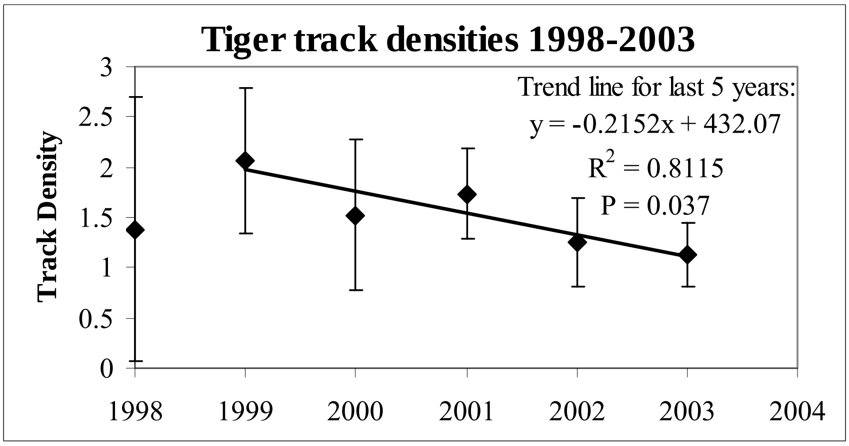


Figure 25. Density of tiger tracks (tracks/100 km/days since last snow) as indicators of tiger abundance averaged across 16 sites included in the Amur Tiger Monitoring Program; trend line estimated for past 6 years.

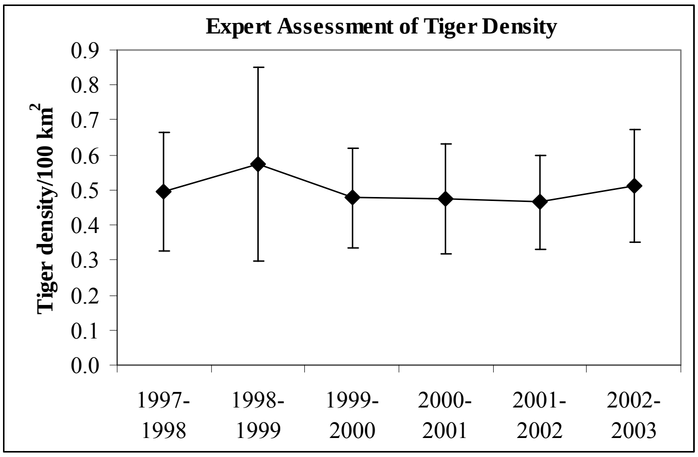


Figure 26. Trend in density of independent tigers (/100 km^2), based on expert assessments, for 16 sites in the Amur Tiger Monitoring Program, 1997-1998 through 2002-2003 winter seasons.

Table 8. Scoring used in development a "scorecard" for each monitoring site

Index		Trend	Score
Tiger abundance			
	Tiger presence	positive trend	3
		negative trend	-3
	Tiger track index	positive trend	3
		negative trend	-3
	Expert assessment	positive trend	3
		negative trend	-3
Ungulate Abundance			
	Red deer	positive trend	2
		negative trend	-2
	Wild boar	positive trend	2
		negative trend	-2
	Sika deer	positive trend	2
		negative trend	-2
	Roe deer	positive trend	1
		negative trend	-1
Tiger Reproduction in past 4 years			
	Cubs in all 4 years		3
	Cubs in 3 of 4 years		2
	Cubs in 2 of 4 years		0
	Cubs in 1 of 4 years		-2
	Cubs in 0 of 4 years		-3

Table 9. A scorecard to monitor trends in tiger numbers and key parameters(indices of prey abundance and tiger reproduction) in the 16 monitoring sites of the Amur Tiger Monitoring Program. "+" = postive trend in population index; "-" indicates a negative trend in population index. For details of the scoring system, see text and Table 8.

	Indices of tiger abundance			Track indices of ungulate abundance				Tiger reproduction	Total score
Monitoring Unit	% tiger presence on rtes	Tiger track density	Tiger density (expert assessment)	Red deer track density	Wild boar track density	Sika deer track density	Roe deer track density	Reproduction this year	
Matai Zakaznik			+	+	+			2	9
Lazovski Raion					+			2	4
Tigrini Dom	+	+		-	-		-	2	3
Lazovski Zapovednik			+	-	+	-	-	2	2
Vaksee (Iman)		near sig	-	+			+	2	2
Bikin River								2	2
Sineya (Chuguevski Raion)		+					+	-2	2
Sandagoy (Olginski Raion)				+			+	-2	1
Botchinski Zapovednik		-	+				+	0	1
Borisovkoe Plateau						-		2	0
Khor		-	+		+			-2	0
Terney Hunting lease	-		-		-			2	-6
Ussuriski Zapovednik	-	-		-		-	-	3	-8
Ussuriski Raion					-	-	-	-3	-8
Bolshe Khekhtsirski Zapovednik	-	-	-	+				-3	-10
Sikhote-Alin Zapovednik	-	-	-	-	-			2	-11

Five monitoring sites appear to be areas of concern. Sikhote-Alin Zapovednik and neighboring Terney Hunting Lease both have strong indications that tiger numbers are decreasing as well as wild boar and red deer (Sikhote-Alin only for red deer). The cause for this decline is unclear. Based on radio collared tigers in and around Sikhote-Alin, we do not have evidence that poaching on tigers per se has increased. A decrease in tiger numbers may be related to the decline in wild boar numbers. Many local biologists believe that reproductive success of tigers is tightly linked to wild boar abundance in many regions of the Russian Far East. Disease and/or starvation appear to be responsible for a major die-off of wild boar 4-5 years ago, and as yet there is no sign of recovery. In fact, because tigers highly prefer wild boar, intense predation pressure may be keeping the wild boar population from increasing locally. While this is purely speculation, it will be interesting to watch the dynamics of these species. In the meantime, investigations should begin to insure that other human-related variables are not responsible for the decrease.

Ussuriski Zapovednik and neighboring Ussuriski Raion also have areas of concern. Two of three indicators suggest that tiger numbers may be decreasing in the Zapovednik, and sika deer and roe deer appear to be decreasing in both sites. Ussuriski Zapovednik traditionally has one of the highest tiger densities reported anywhere in the Russian Far East, but it is also one of the closest sites to major centers of human development (with the cities of Ussurisk and Vladivostok within easy driving distance). Therefore changes in the status of tigers and their prey here are of great concern. We recommend that zapovednik staff review their own prey and predator monitoring data to assess the present status of tigers and prey, to identify causes of declines and hopefully initiate intervention activities to reverse these trends.

Despite a pattern of decreasing reproductive activity in Khabarovsk (see last years report) the only site in Khabarovsk that appears to be an area of concern is Bolshe-Khekhtsirski Zapovednik. This small island of habitat, although harboring high (apparently increasing) numbers of red deer and wild boar, is simply too small, and too close to the city of Khabarovsk, to maintain a stable tiger population. This island of habitat is likely to experience frequent localized extinctions and recolonization, as long as some form of connectivity can be maintained with the main Sikhote-Alin population. In fact, improving stability of this population may be dependent more on securing a corridor to the Sikhote-Alin than any internal management or manipulations of the zapovednik per se.

V. REPORTS ON INDIVIDUAL MONITORING SITES 2002-2003

Introduction

Following are brief summaries of each monitoring site. For each site, a summary of the highlights and results of the year are provided by the coordinator for that site. Additionally, a map of the area, including location of survey routes, location of tiger tracks reported on survey routes during both surveys (early and late winter) and location of tiger tracks reported off survey routes (or reported at another time than the actually survey) is also provided. These track data provide the basis for the three estimators of tiger abundance (presence/absence, track density, and number of independent tigers) (see Section I), each of which is summarized in a graph for the first four years of the monitoring program for each site. A summary table of the sex-age distribution of tigers in each site, based on expert assessments is also provided, which includes information on reproduction. Ungulate track density estimators are summarized in a table, and for comparative purposes, in a bar graph as well.

Some sites, such as Ussuriski Zapovednik and Ussuriski Raion, or Sikhote-Alin Zapovednik and Terney Hunting Society, are reported on together by the single coordinator responsible for them. All 5 sites in Khabarovsk are reported on together by Yu. M. Dunishenko, who provides an excellent assessment of conditions there.

In summary, results of this year's monitoring program at each of these sites represent a "snap-shot" of conditions existing across tiger range in the Russian Far East. By reviewing the sum of these data it is possible to derive a better understanding of the variation in conditions across this vast area inhabited by tigers, and to better appreciate local variations, trends, and conditions for tigers and their prey base.

LAZOVSKI ZAPOVEDNIK

Southeast Primorsky Krai

Report on results of Amur tiger monitoring program in Lazovsky Zapovednik monitoring unit in winter 2002-2003 Coordinator - G. P. Salkina, Lazovsky State Zapovednik

1. *Name of model unit:* Lazovsky Reserve
2. *Coordinator*: G. P. Salkina
3. *Time of simultaneous counts*: December 22-25 and February 17-18 (except survey route # 4, which was traveled on 26th of December and 19th of February)
4. *Routes ##*: 1-12
5. *Total length of routes*: All survey routes (total length is about 130 km) were traveled on foot. During the 2nd survey routes # 9 was not covered completely (about 2 km less).
6. *Survey conditions*: The survey was conducted 6-7 days after last snowfall. Snow depth on the seashore varied from 0 cm on southern slopes to 7 cm in valleys. In inland part of the Reserve snow depth varied from 5 to 60 cm. Heavy snowfall took place on January 27. February survey was conducted 21-22 days later. At that time snow depth varied from 3 cm to 27 cm on the seashore and from 5 to 68 cm in valleys inland.

7. *Assessment of efficiency*: In December survey routes were covered on skies because of deep snow. Weather conditions were favorable for data collection. In February thaws took place but snow did not stick to skies and routes were covered relatively easy. It was difficult to determine track age and to make measurements because of the thaw.

8. *Results:*

   Status of ungulate populations

   Such tiger prey species as wild boar, red deer, sika deer, roe deer, musk deer and goral inhabit the territory of model unit. There was no rich harvest of acorns and pinecones in fall 2002. In 2002-2003 winter season wintering conditions for ungulates were moderate in the study area. Virtually there were no precipitations in February and March. In the second half of winter weather was not very frosty and thaws often took place.

Only one case of poaching (sika deer) was revealed in the Reserve in 2002. The number of poached ungulates decreased in comparison with previous years. But the most likely reason of that is the decrease of ungulate numbers. Sika deer density decreased twice in comparison with previous year. The reduction of number of sika deer tracks was especially evident in inland part of the Reserve. Encounter rate of wild boar tracks remained the same and encounter rate of red deer and roe deer tracks decreased more than 4 times.

Status of tiger population in comparison with previous information

In 2001-2002 monitoring of tiger population was conducted with the help of special trained dogs, which identified tigers. Three males, four females and one animal of unknown sex were identified. One more female was identified by her tracks. One of the identified females was registered only once in 2001. It was also determined that in late December female with cubs moved from northeastern part of the seashore to the southwest. Here she killed a dog and brought it to her cubs. Later one cub (male, 4-5 months old) was found dead near the remains of the dog. To all appearances tiger cub was smothered (his trachea was bitten through). No tracks of predators, including tracks of adult male tiger, were found nearby. Most likely the cub was smothered by another cub from the litter.

Winter transect count was conducted in the Reserve on December 17-18, 2002 immediately after snowfall. 8-9 adult and subadult tigers and 2 cubs were registered. The number of tigers (except cubs) slightly decreased in comparison with previous year and 1995-1996 winter season. In comparison with early 1990-s in Lazovsky Reserve tiger numbers decreased almost twice.

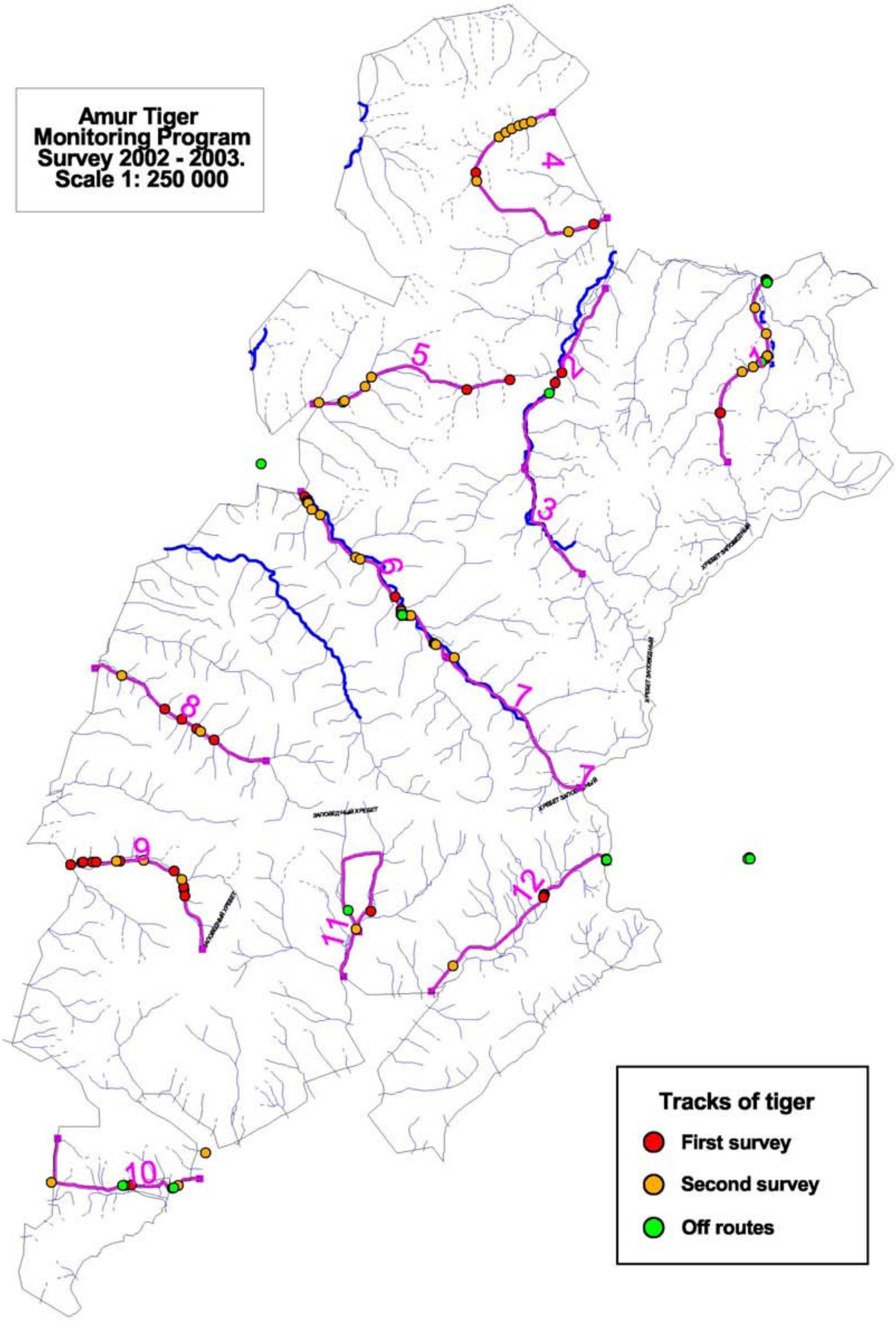
Status of habitat

In 2002 three fires (area of 6.3 ha) took place in the Reserve. It is much less than in previous years.

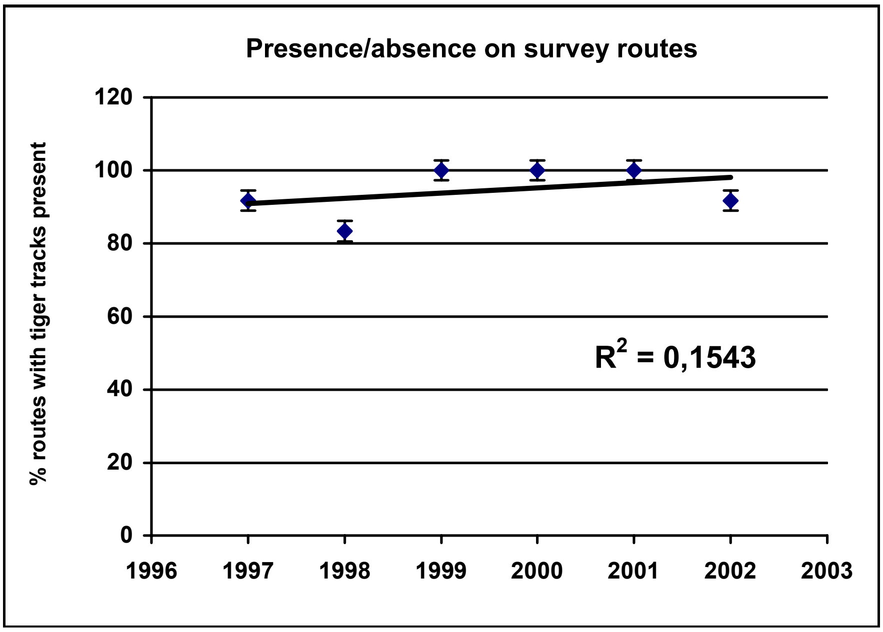
Recreational (human) pressure in southeastern part of the reserve remains high. In warm season many people cross the reserve territory to get into the bay nearby. Due to this fact, tiger track encounter rate in this territory significantly decreased.

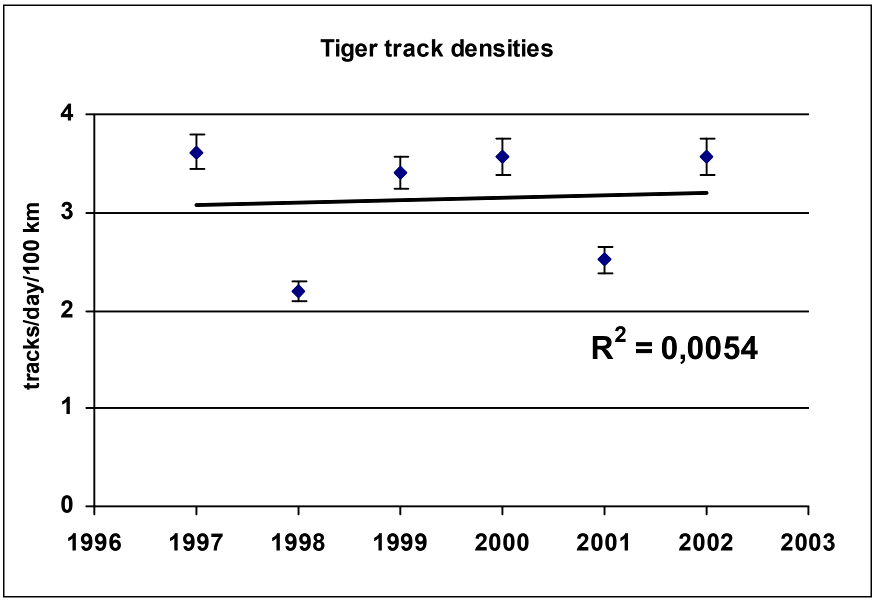
Ungulate densities are influenced by poaching, which takes place mostly along the reserve borders and its buffer zones, where ungulates stay from time to time.

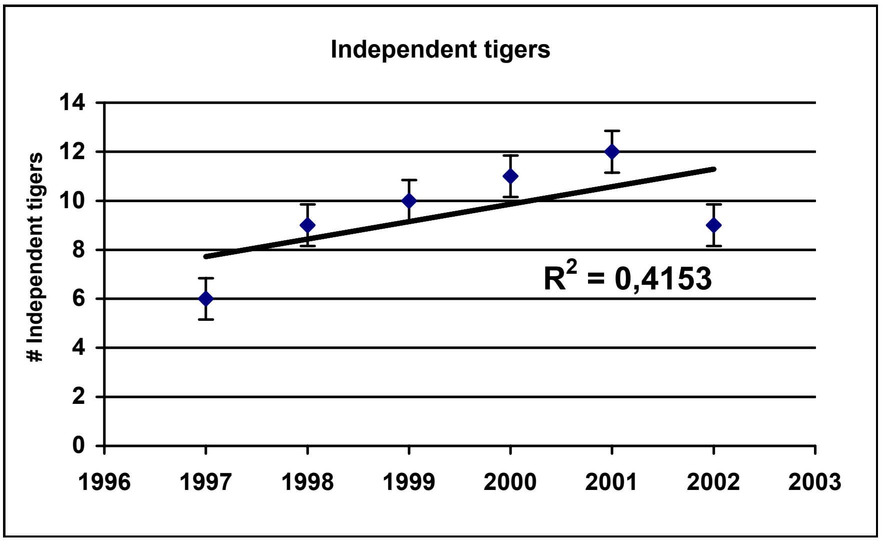
Model unit "Lazovski zapovednik"



Designed and printed by GIS-Center "TIGIS" 25.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1543


Tiger track densities
tracks/day/100 km
4
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,0054

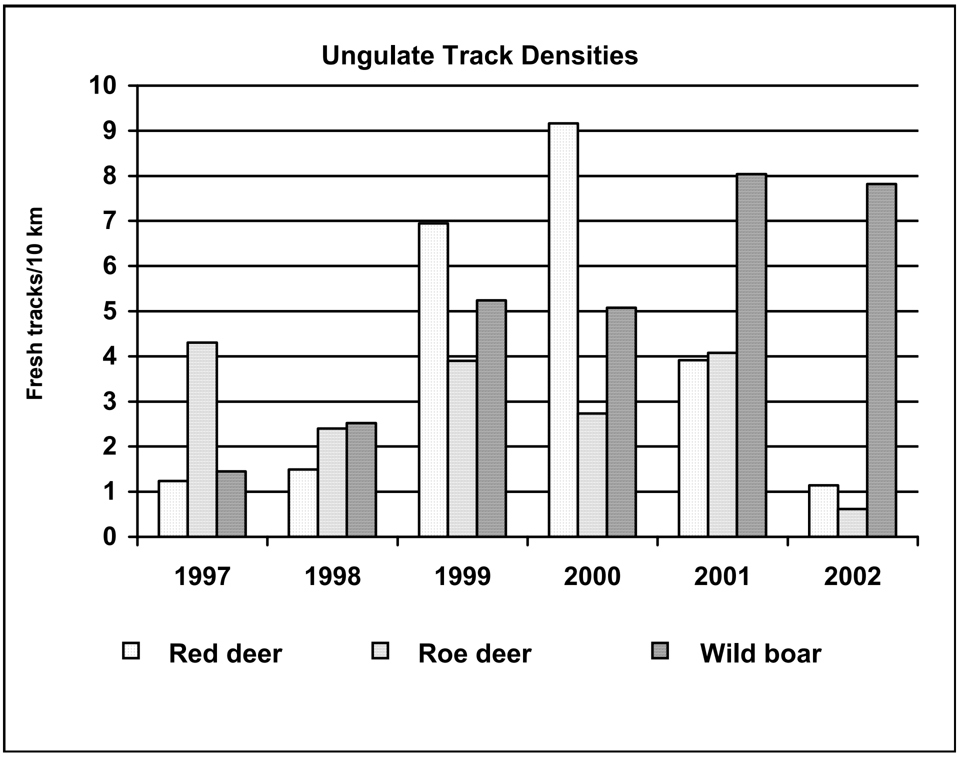

Independent tigers
Independent tigers
14
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,4153

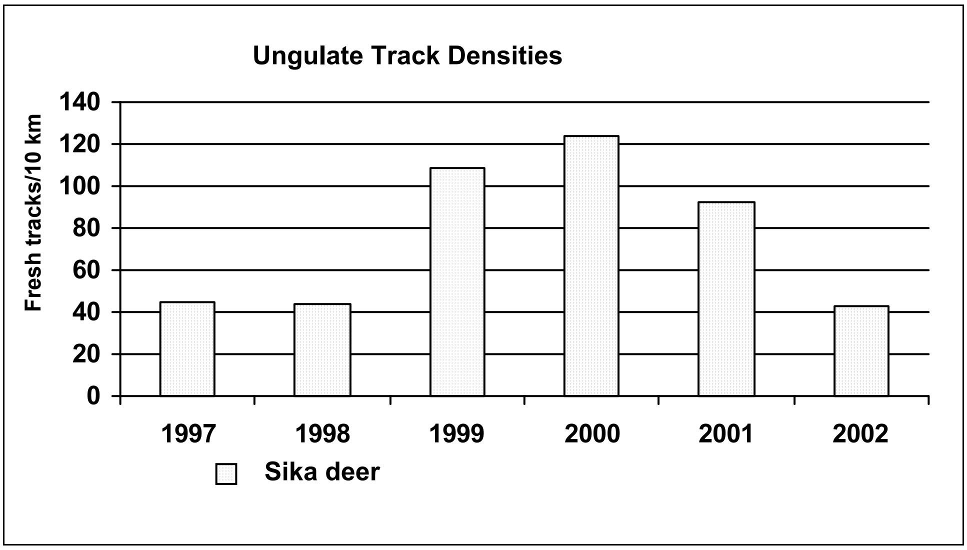
Number of tigers, by age class and sex (for adults only) in "Lazovsky Zapovednik" Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	0	1	1	0	2	5	2	7	9
1998	0	2	2	0	2	7	4	11	13
1999	3	4	1	0	0	3	8	11	11
2000	1	2	1	0	5	8	4	12	17
2001	1	5	0	1	4	5	6	11	15
2002	3	5	0	0	6	1	8	9	15

Mean track density (tracks less than 24 hours) of ungulates in "Lazovsky Zapovednik" Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	12	1.23	2.41	4.30	9.15	45.18	60.95	1.45	3.24
1998	12	1.49	3.22	2.40	3.73	43.85	54.79	2.52	3.55
1999	12	6.94	22.66	3.90	6.38	108.28	177.70	5.24	15.24
2000	12	9.16	14.79	2.73	3.94	123.38	158.15	5.08	8.73
2001	12	3.92	8.45	4.07	7.02	92.46	106.01	8.04	17.38
2002	12	1.14	2.89	0.62	1.85	42.71	54.13	7.82	16.23
Total mean		3.98	9.07	3.00	5.35	75.98	101.96	5.03	10.73





Ungulate Track Densities
Fresh tracks/10 km
140
120
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
Sika deer

LAZOVSKI RAION
Southeast Primorsky Krai

Report on results of Amur tiger monitoring program in Lazovsky Raion model unit in winter 2002-2003
Coordinator - G. P. Salkina, Lazovsky State Zapovednik

1. *Name of model unit*: Lazovsky raion - Krivaya river basin and seashore.
2. *Coordinator*: G. P. Salkina
3. *Time of surveys*: January 12-15 and February 21-24.
4. *Routes ##:* 1-11
5. *Total length of routes*: 10 routes were traveled on foot and 1 – by vehicle. Total length of survey routes is about 140 km.
6. *Survey conditions*: Heavy snowfalls took place on December 16-17, 2002 and January 3, 2003. In January the survey was conducted 14-17 days after snowfall. No snowfalls happened after that time and therefore a lot of old tracks hampered the February survey.

7. *Assessment of efficiency:* At the time of the first survey the weather was frosty and allowed estimating track age and making measurements. In February it was slightly more difficult to do this because of the thaw. Some routes on southern slopes were partly free of snow.

8. *Results*:

Status of ungulate populations

Such tiger prey species as wild boar, red deer, sika deer and roe deer inhabit the territory of model unit. There was no rich harvest of acorns and pinecones this season. This winter season wintering conditions for ungulates were moderate. From the middle of January through February thaws often took place, there were no snowfalls in March.

Sika deer track encounter rate decreased 1.5 times in comparison with previous year. Roe deer numbers also decreased greatly. Red deer density remains low and wild boar density is the same as in previous year. In the area, where survey routes are set, the number of red deer tracks is several times less than the number of issued hunting licenses for the species. On some routes fresh ungulate tracks were not found.

The most part of sika deer population resides in the eastern part of model unit, which is protected by private guards.

No cases of poaching ungulates were revealed in the study area. The number of poached ungulates decreased because ungulate densities decreased as well.

Status of tiger population in comparison with previous information

In comparison with previous year the number of adult tigers did not decline significantly, but the number of cubs dropped sharply (only one tiger cub was found). On the other hand, tiger tracks were found on the routes, where they were absent two years ago. Tiger numbers and density are much less than in 1995-1996.

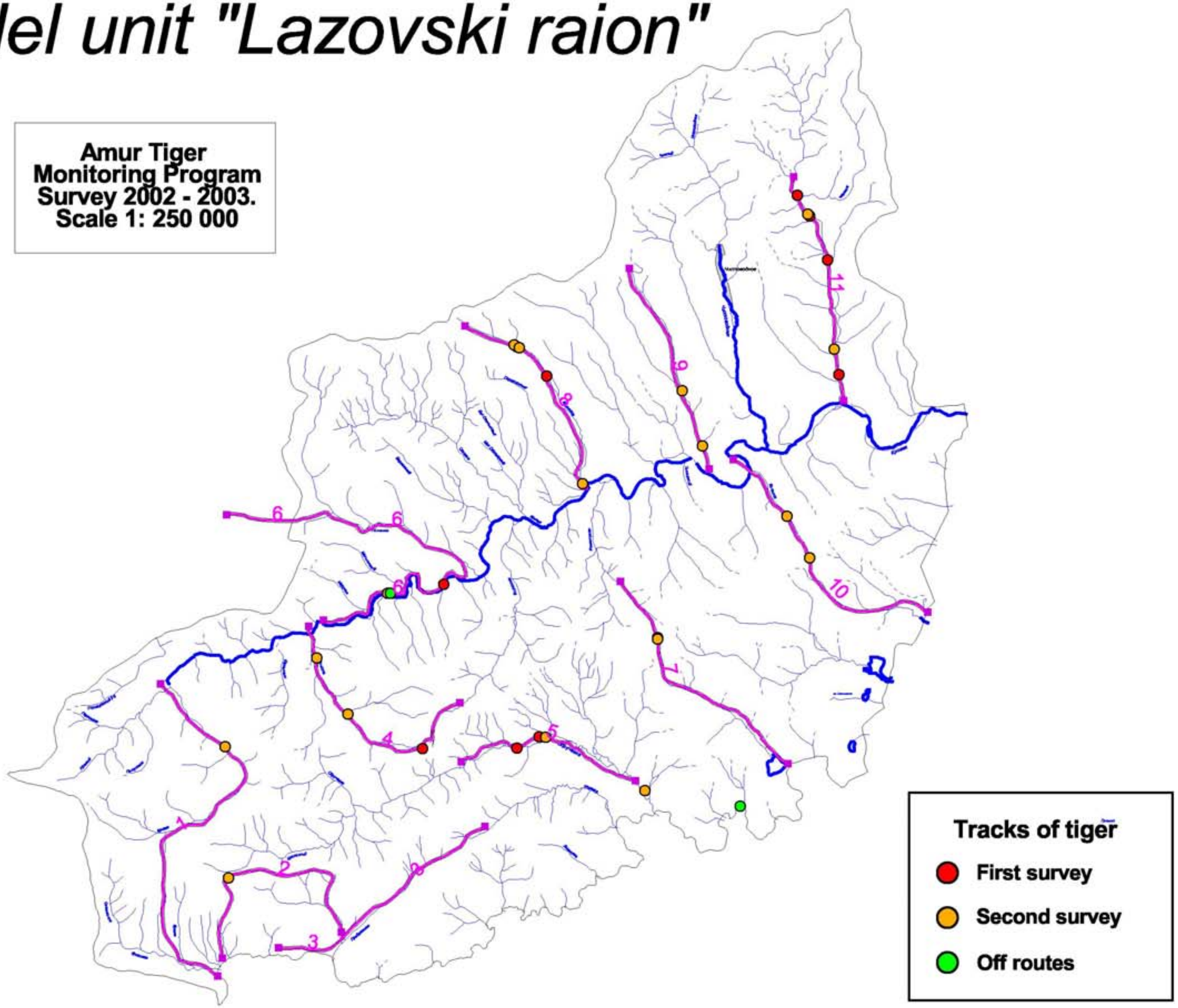
Status of habitats

During this year, no considerable movements of human population happened in this model unit. Slight decrease of human population is observed in settlements around the model unit. The number of wood-cutting sites as well as logging areas decreased slightly in comparison with previous year. In those parts of model unit, which are often visited by people, the number of ungulate tracks is significantly lower.

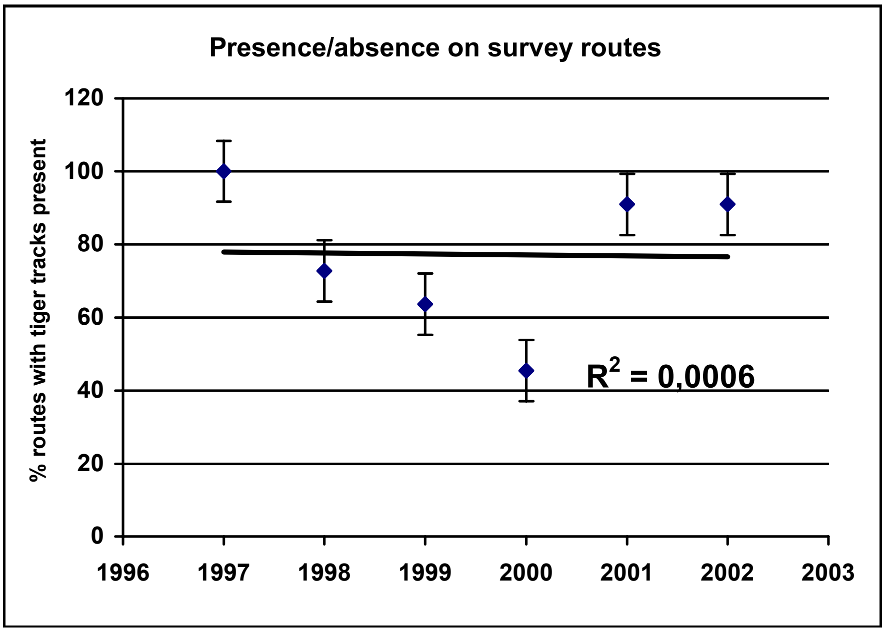
According to the information obtained from local forestries and local people, no fires happened last year in this model unit.

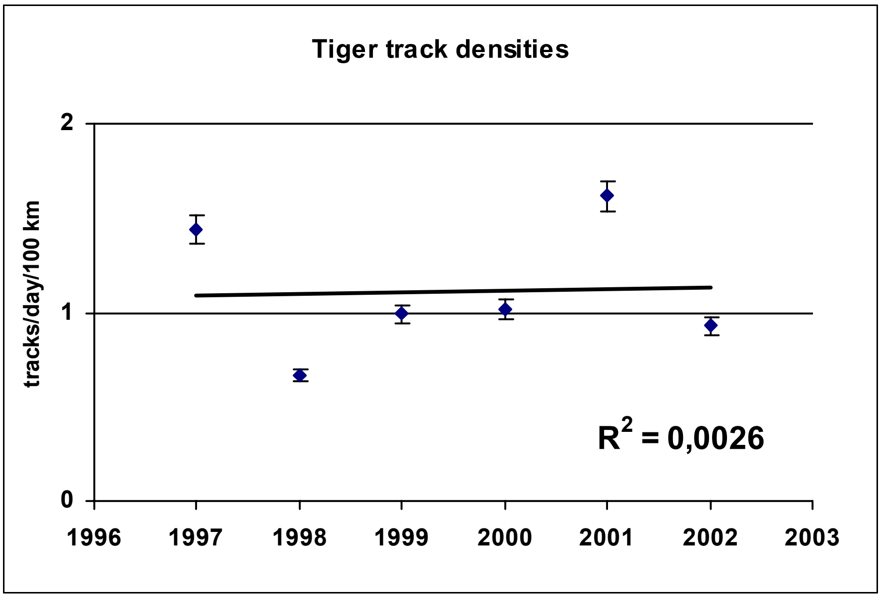
Recreational pressure from citizens of adjacent densely populated Partizansky raion in model unit remains high. In summer many people are looking for ginseng here.

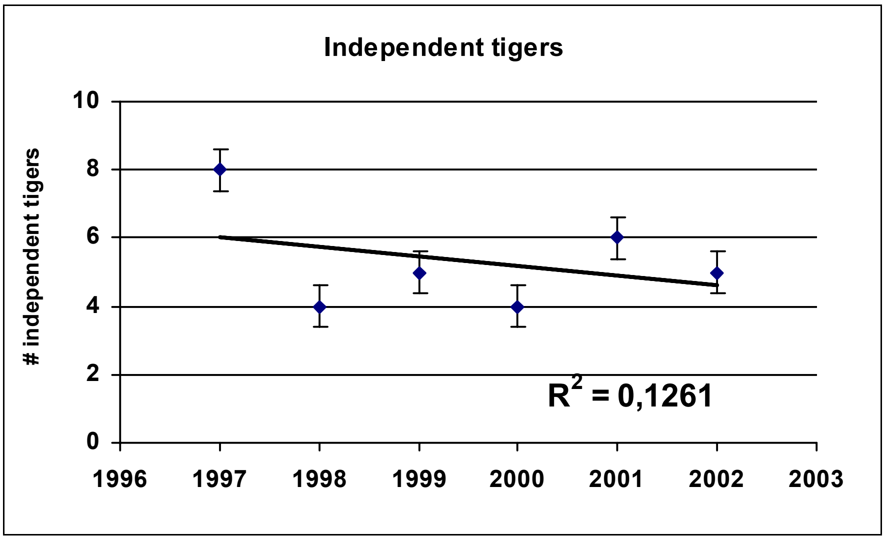
Model unit "Lazovski raion"



Designed and printed by GIS-Center "TIGIS" 25.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,0006


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,0026

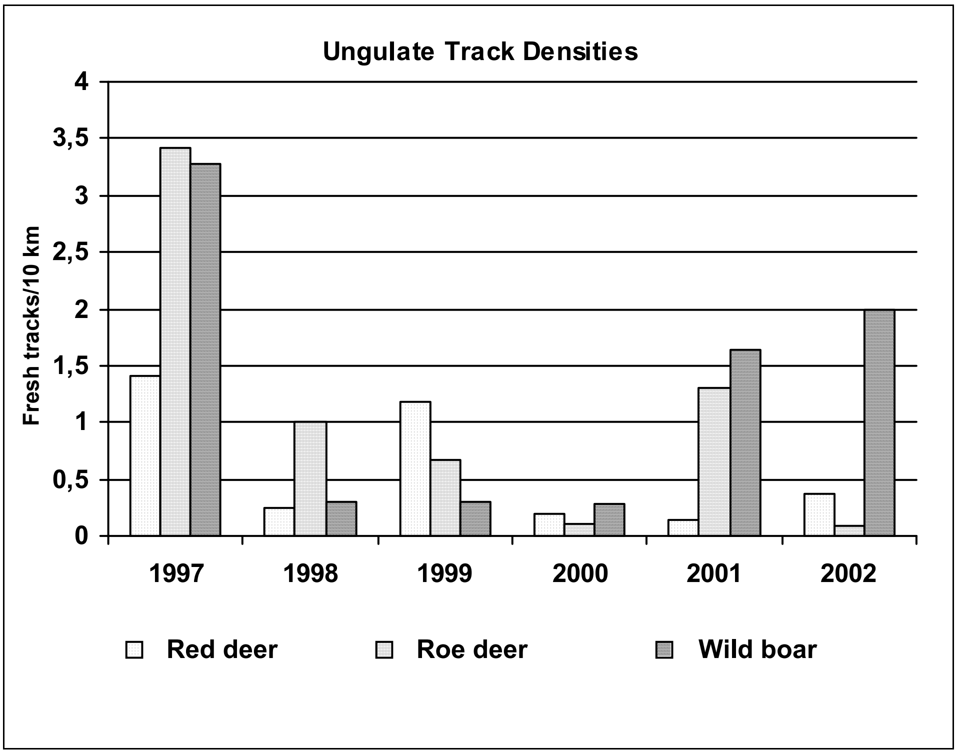

Independent tigers
independent tigers
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,1261

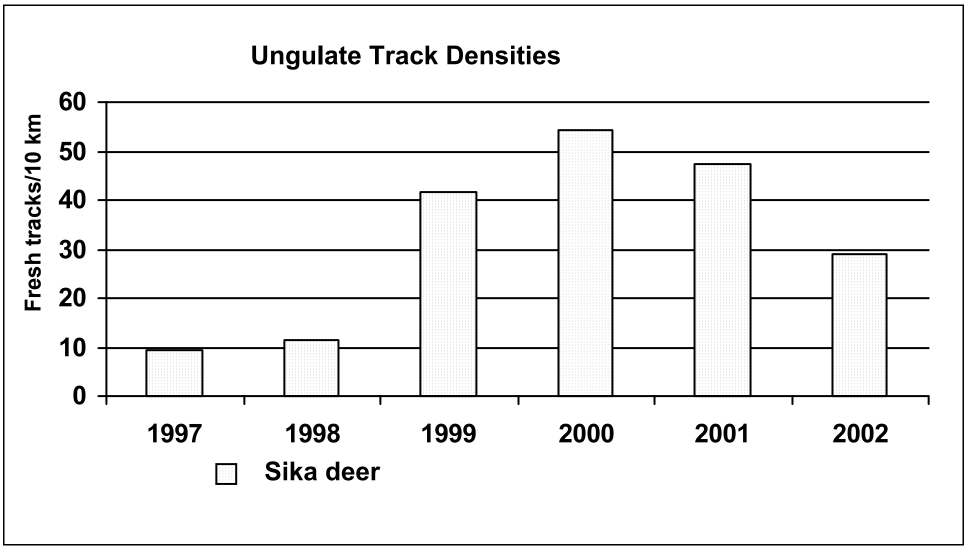
Number of tigers, by age class and sex (for adults only) in "Lazovsky Raion" Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	0	2	2	0	2	6	4	10	12
1998	0	1	0	0	2	3	1	4	6
1999	3	1	0	0	0	1	4	5	5
2000	0	2	1	0	4	2	3	5	9
2001	1	4	0	0	8	1	5	6	14
2002	3	2	0	0	1	0	5	5	6

Mean track density (tracks less than 24 hours) of ungulates in "Lazovsky Raion" Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	11	1.41	3.66	3.42	7.67	9.31	8.06	3.28	2.41
1998	11	0.25	0.82	1.01	1.27	11.43	18.81	0.3	0.67
1999	11	1.18	5.32	0.67	2.06	41.79	76.25	0.3	0.75
2000	11	0.19	0.68	0.11	0.52	54.1	117.39	0.28	0.87
2001	11	0.14	0.64	1.3	2.02	47.3	141.62	1.63	2.31
2002	11	0.36	1.5	0.1	0.31	28.96	34.79	1.99	4.4
Total mean		0.59	2.1	1.1	2.31	32.15	66.15	1.3	1.9




Ungulate Track Densities
Fresh tracks/10 km
60
50
40
30
20
10
0
1997
1998
1999
2000
2001
2002
Sika deer

USSURIISKY ZAPOVEDNIK
South-central Primorsky Krai

Report on results of Amur tiger monitoring program in Ussuriisky Zapovednik model unit in winter 2002-2003 Coordinator - V.K. Abramov, Ussuriisky State Zapovednik

Assistant coordinators: Kovalev V.A. – Ussuriisky Raion, Kosach S. P. – Shkotovsky Raion

The territory of Zapovednik is 40,432 ha.

Number of routes – 11 (## 1, 5-8, 12, 14, 15, 17, 22, 23), total length of routes – 100.8 km, including 1 route traveled by vehicle (16.6 km) and 10 routes traveled on foot (84.2 km).

In 2002 heavy snowfall happened early (in late October snow fell on moist soil) and caused changes in distribution and activity of tiger prey species. Ungulates became less active and concentrated in confined areas. Tigers, especially females with cubs, became less active as well. This year the 1st survey was conducted a month earlier than usual due to early snowfall - on November 25-27 and the 2nd survey was conducted on February 4-6.

By the end of November snow depth had decreased significantly in comparison with first days after snowfall in October. Snow cover had settled and its depth varied from 30 to 40 cm, and in some places reached 50 cm and even 70 cm.

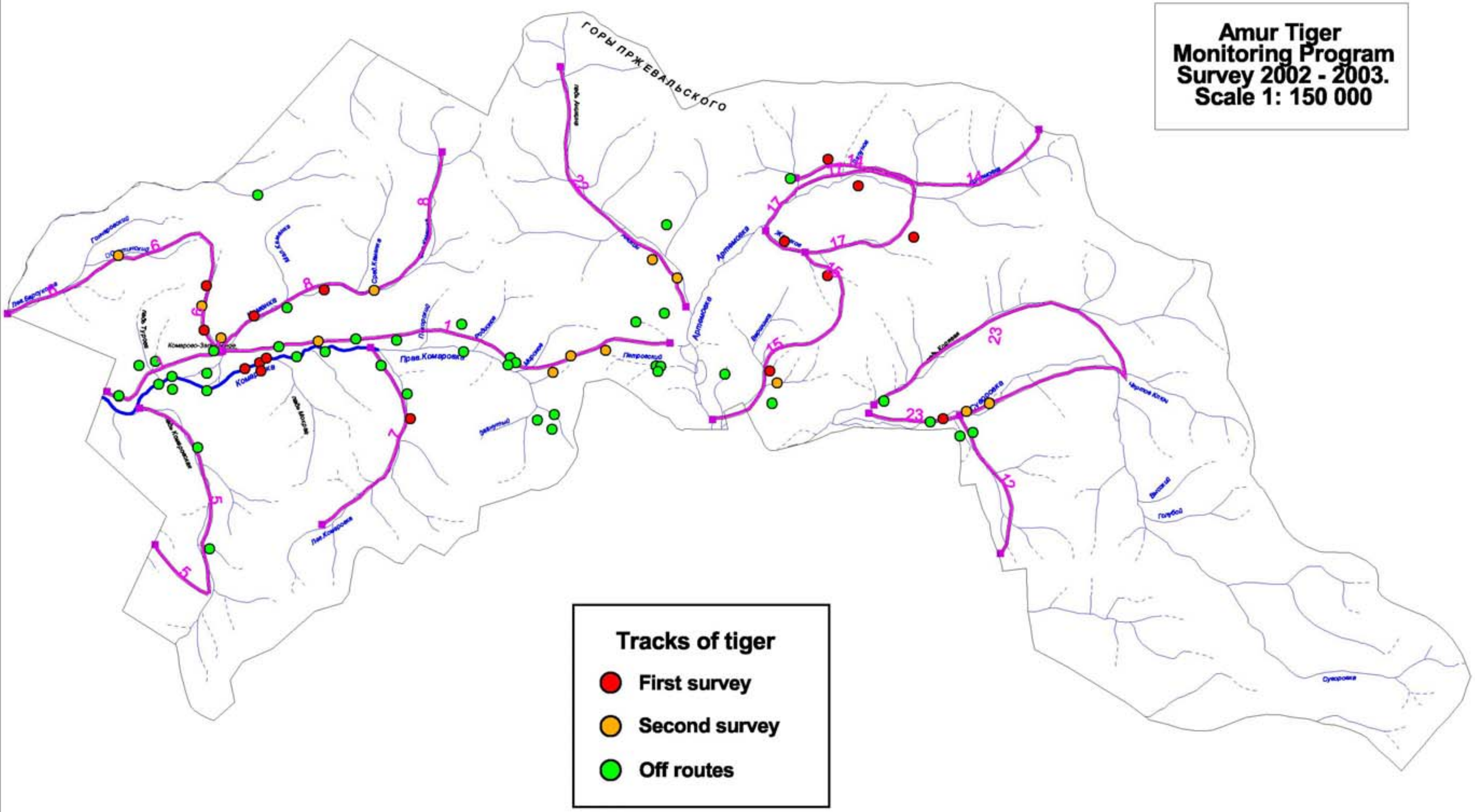
By February snow cover (even after snowfall in January) had settled on southern slopes and its depth did not exceed the snow depth in November. Only on northern slopes and forested ridges snow cover was up to 70-75 cm and even 80 cm deep.

Tiger tracks encounter rate was low during the whole winter season. The main reason of this was long-term concentration of ungulates on confined areas caused by deep snow cover.

Survey routes along the unused parts of roads were difficult to cover because they were not passable without the help of tractors because of deep snow.

Despite the total decrease of ungulate populations, except sika deer, the number of tigers in Zapovednik has grown: in April or May female gave birth to 3 cubs in Solontsovy creek area. By November all 3 cubs were alive, but then 1 cub died between December, 2002 and February, 2003. The cause of its death is unknown. By the time of February survey 2 females with cubs resided in the territory of Zapovednik. One litter consisted of two cubs more than 1 year old. Cubs in the second litter were younger than 1 year.

Model unit "Ussuriyski zapovednik"



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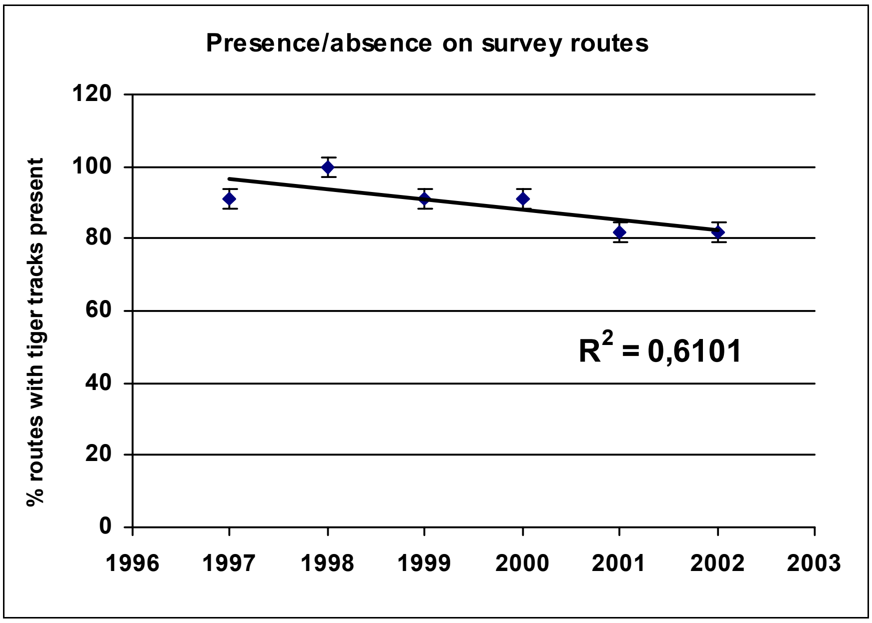
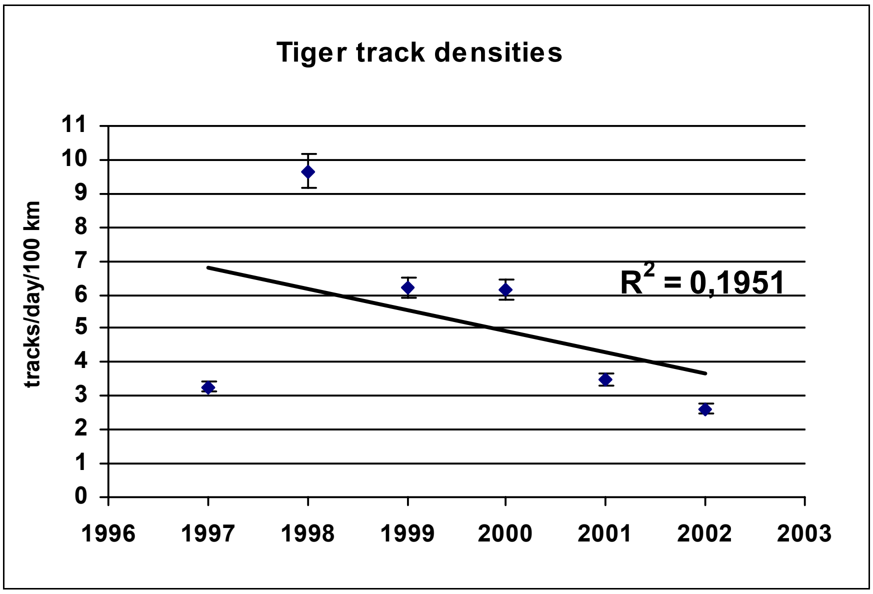
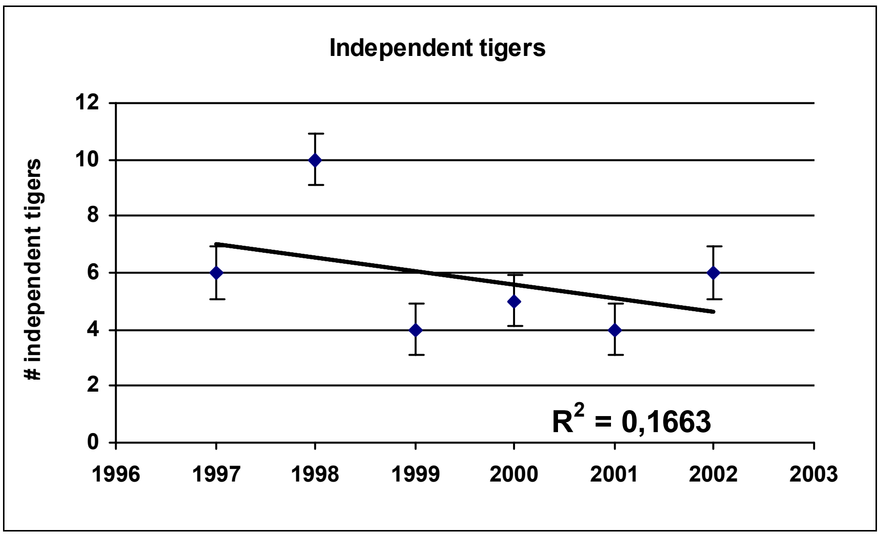

Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,6101


Tiger track densities
tracks/day/100 km
11
10
9
8
7
6
5
4
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1951

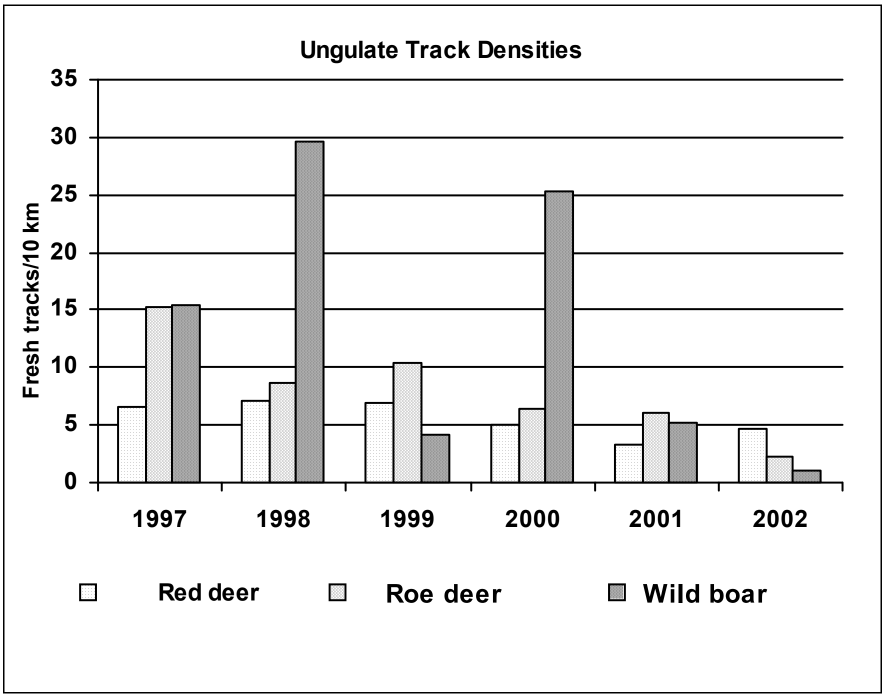

Independent tigers
independent tigers
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1663

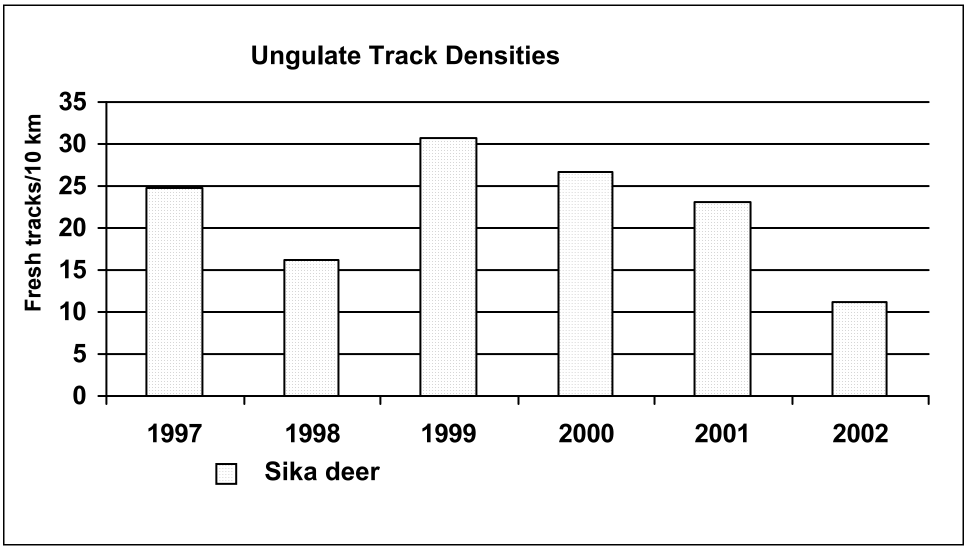
Number of tigers, by age class and sex (for adults only) in “Ussuriisky Zapovednik” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	1	1	1	1	2	3	5	6
1998	0	1	5	2	0	7	6	13	13
1999	1	2	1	0	3	1	4	5	8
2000	2	2	0	0	2	0	4	4	6
2001	1	2	0	0	2	0	3	3	5
2002	2	4	0	0	5	0	6	6	11

Mean track density (tracks less than 24 hours) of ungulates in “Ussuriisky Zapovednik” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	23	6.66	10.02	15.2	20.08	24.81	28.54	15.5	20.55
1998	23	7.03	7.25	8.61	11.31	16.12	19.58	29.56	35.2
1999	23	6.98	8.21	10.33	11.03	30.72	51.08	4.13	5.99
2000	23	5.03	5.22	6.49	6.54	26.65	35.67	25.21	35.51
2001	23	3.33	4.87	6.14	6.41	23.09	26.68	5.25	10.63
2002	23	4.66	4.31	2.18	3.12	11.18	15.48	0.99	1.77
Total mean		5.62	6.65	8.16	9.75	22.09	29.51	13.44	18.28




Ungulate Track Densities
Fresh tracks/10 km
35
30
25
20
15
10
5
0
1997
1998
1999
2000
2001
2002
Sika deer

USSURIISKY RAION

South-central Primorsky Krai

Report on results of Amur tiger monitoring program in Ussuriisky Raion model unit in winter 2002-2003

Coordinator - V.K. Abramov, Ussuriisky State Zapovednik

Assistant coordinators: Kovalev V.A. – Ussuriisky Raion, Kosach S. P. – Shkotovsky, Mikhailovsky Raions

The territory of model unit is adjacent to zapovednik and covers 141,926 ha.

Number of routes – 13 (## 2-4, 9-11, 13, 16, 18-21, 24), total length of routes – 198.1 km, including 75.9 km traveled by vehicle and 122.2 km traveled on foot. This year the 1st survey was conducted a month earlier than usual due to early and heavy snowfalls, which happened in late October. The 1st survey was conducted on November 25-27 and the 2nd survey was conducted on February 4-6.

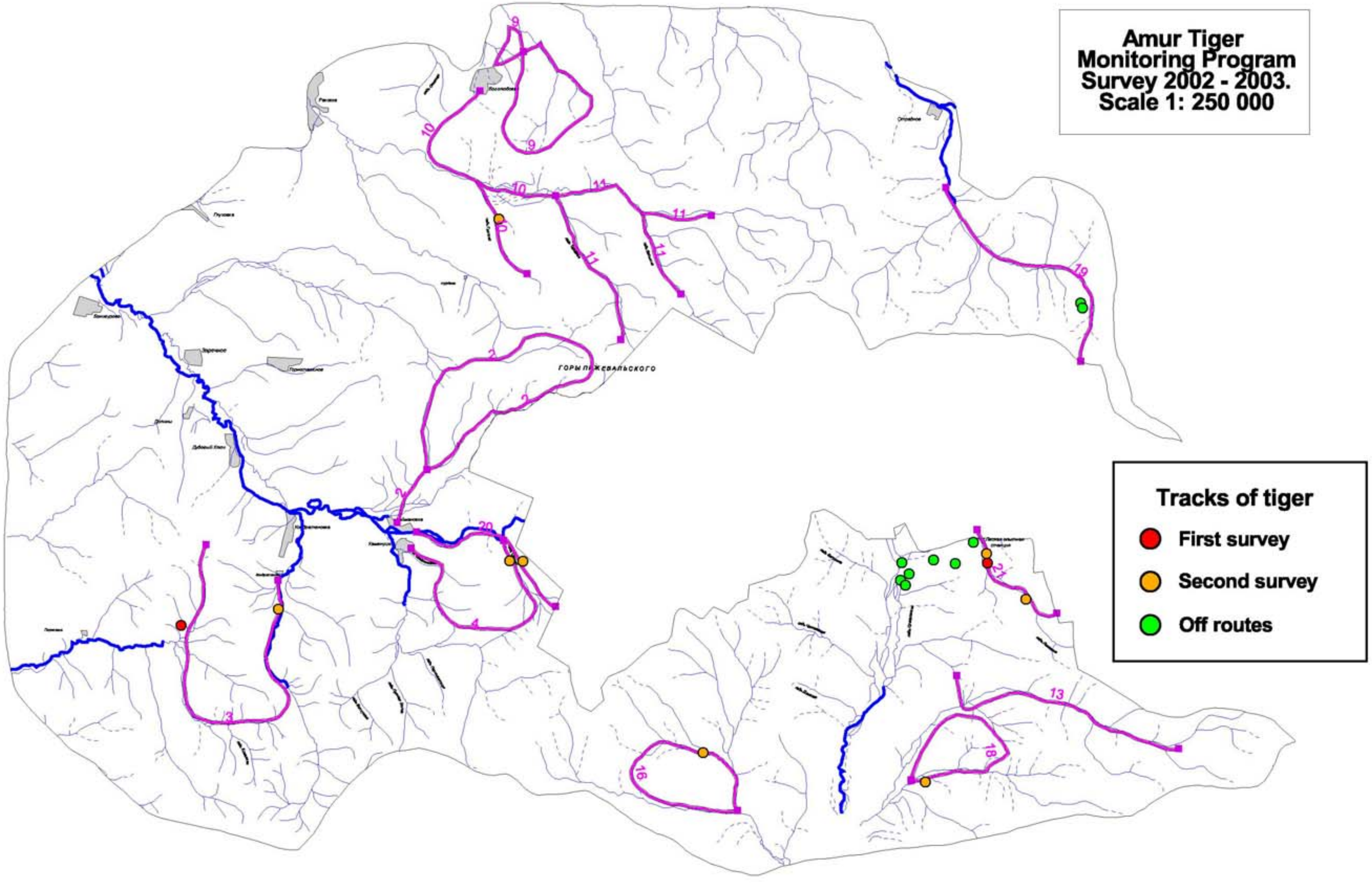
*Survey conditions***.** In November snow depth mostly exceed 30 cm and in some places snow cover was 50 cm and even 70 cm deep. By February snow cover (even after snowfall in January) had settled on southern slopes and its depth did not exceed the snow depth in November. Only on northern slopes and forested ridges snow cover was up to 70-75 cm deep.

Survey efficiency (tiger tracks encounter rate) was low especially in February. The main reason of this was long-term concentration of predators on confined areas caused by heavy snowfall.

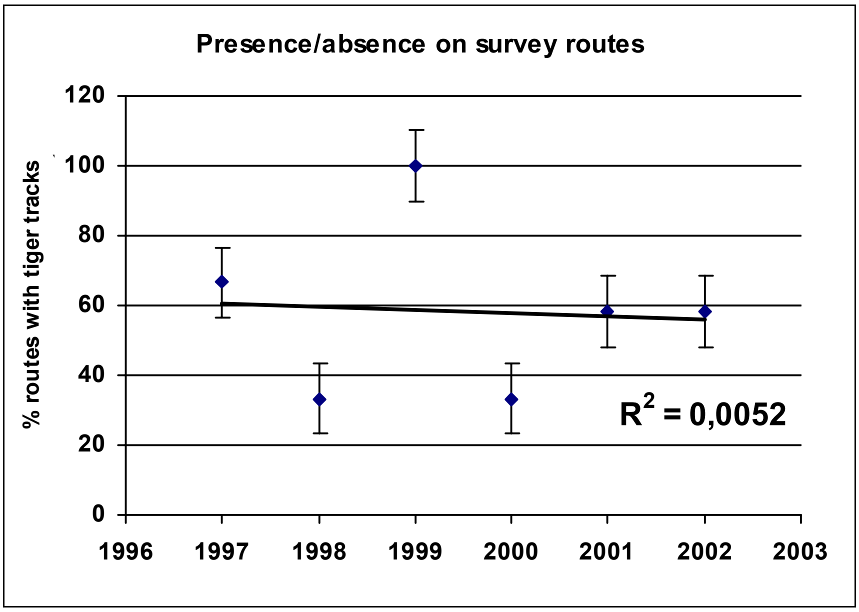
Survey routes along the unused parts of roads were difficult to cover because they were not passable without the help of tractors because of deep snow.

Despite the decrease of human disturbance due to poor harvest of pinecones the numbers of ungulates continue to decrease. However the number of tigers has increased. Besides transit tigers (from Zapovednik) one female was wintering in Kamenushka and Perevoznaya river basins, one - in Bolshaya and Malaya Soldatka river basins, female with cub visited model unit traveling along Ilistaya river.

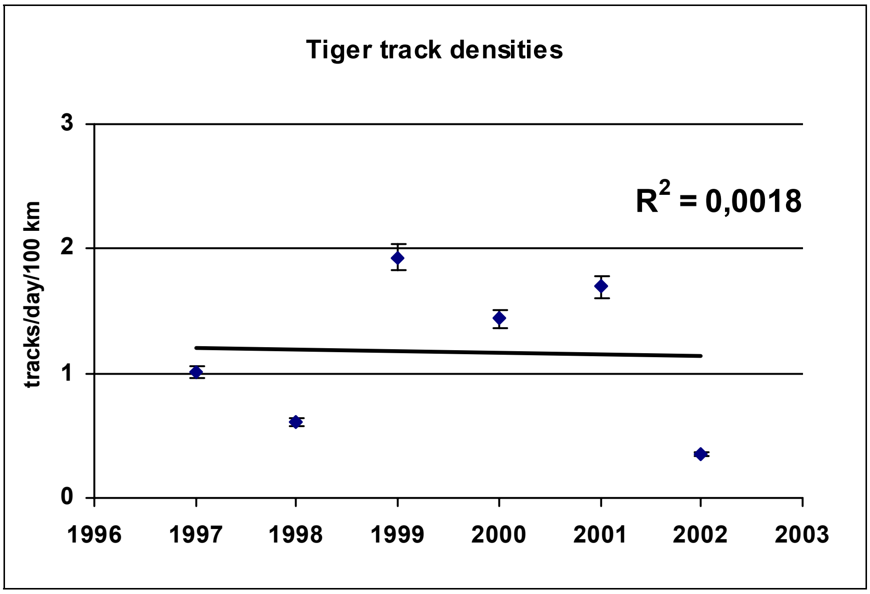
Model unit "Ussuriyski raion"



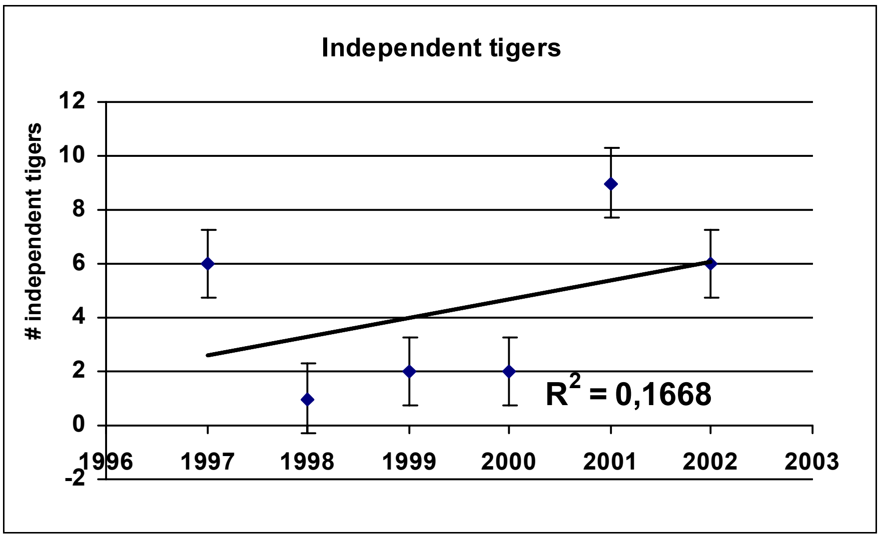
Designed and printed by GIS-Center "TIGIS" 25.12.2003



Presence/absence on survey routes
% routes with tiger tracks
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,0052



Tiger track densities
tracks/day/100 km
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,0018



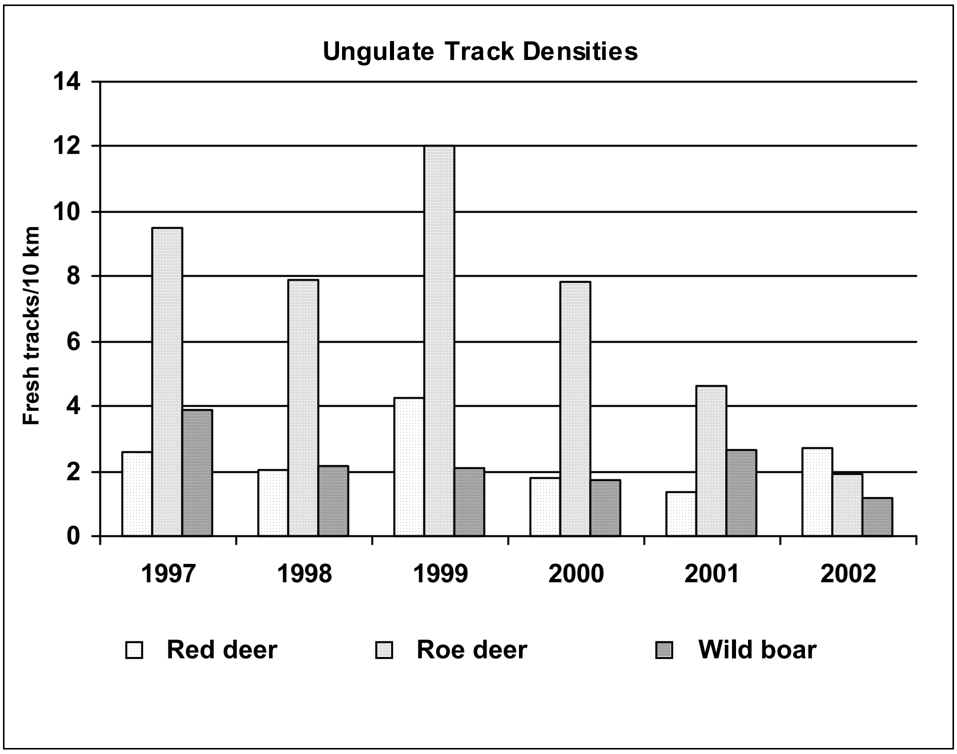
Independent tigers
independent tigers
12
10
8
6
4
2
0
-2
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1668

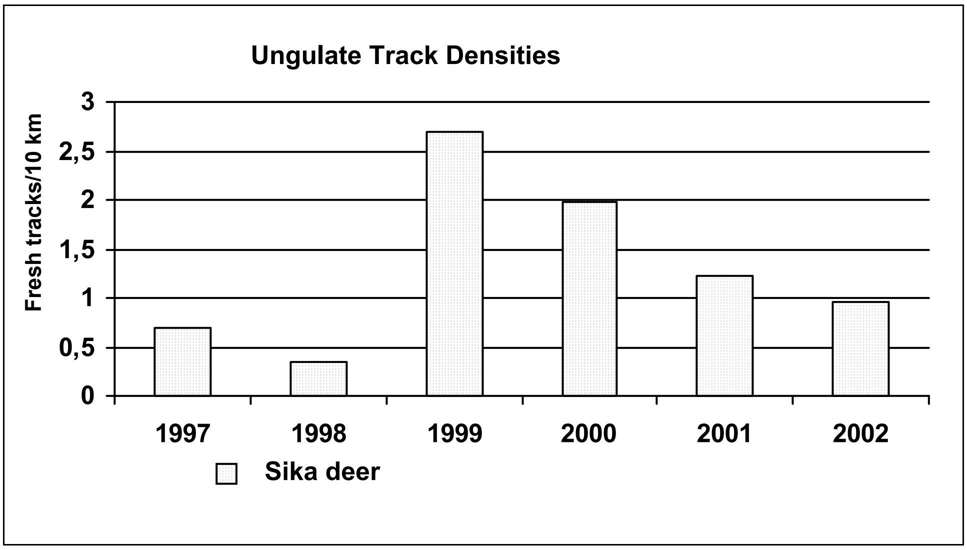
Number of tigers, by age class and sex (for adults only) in "Ussuriisky Raion" Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	2	0	3	0	0	3	3	3
1998	0	1	0	0	2	0	1	1	3
1999	1	1	0	0	0	0	2	2	2
2000	1	1	0	0	0	0	2	2	2
2001	2	2	0	1	0	0	4	4	4
2002	0	3	0	0	0	0	3	3	3

Mean track density (tracks less than 24 hours) of ungulates in "Ussuriisky Raion" Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	21	2.59	4.39	9.52	12.18	0.7	1.57	3.89	4.64
1998	21	2.02	2.45	7.92	9.43	0.34	1.09	2.19	3.7
1999	21	4.28	5.63	12.05	9.29	2.69	4.33	2.07	3.03
2000	21	1.79	2.39	7.86	6.33	1.98	3.37	1.71	3.7
2001	21	1.38	1.99	4.65	5.03	1.23	2.68	2.66	4.18
2002	21	2.72	3.69	1.9	2.43	0.96	1.96	1.19	1.98
Total mean		2.46	3.42	7.32	7.45	1.32	2.5	2.28	3.54




Ungulate Track Densities
Fresh tracks/10 km
3
2,5
2
1,5
1
0,5
0
1997
1998
1999
2000
2001
2002
Sika deer

BORISOVSKOE PLATEAU
Southwest Primorsky Krai

Report on results of Amur tiger monitoring program in Borisovskoe Plateau monitoring unit in winter 2002-2003
Coordinator - D.G. Pikunov, Pacific Institute of Geography, Far Eastern Branch Russian Academy of Sciences

Borisovskoe Plateau model unit in Southwest Primorye was established to monitor populations of Amur tiger, Far Eastern leopard and wild ungulates. Additionally we attempt using some parameters to assess quality of habitats of predators and ungulates, which are the main object of sport hunting here.

In February 2003 within the whole territory of Southwest Primorye sweep survey of leopards, tigers and ungulates was conducted by experienced specialists. WCS provided considerable funds for this work and 151 survey routes were established within the whole forested area of Southwest Primorye. The aim of this survey was to determine the number and distribution of leopards, tigers and wild ungulates in this area.

Data obtained from Borisovskoe Plateau model unit and comparison of this information with data obtained from sweep survey within the whole territory of SWP showed some patterns/tendencies. Specifically, we had a chance to assess – the accuracy of extrapolation of model unit predator population surveys for the whole of SWP habitat. Comparison of data on predators' number within the model unit and on the whole territory of SWP revealed specific mechanisms. It is important because annual investigation of the whole territory of SWP is not always possible due to weather conditions and is laborious and expensive as well. The purpose of this survey, aside from direct monitoring tasks, is to determine the number of predators and ungulates in the whole territory of SWP based on data obtained within model unit (i.e. the area of 100-120,000 ha or 25% of all suitable habitats of SWP). No doubt that single comparison of such data is insufficient for valid and reliable conclusions. Still, with collection of similar data for a number of years and taking into account the annual environmental changes and connected with them intensity of animal migrations, eventually it will become possible to more accurately calculate predator and ungulate populations for the whole of SWP based on model unit surveys alone. In the last section of our report we submit out calculations.

Survey conditions

1st survey was conducted on December 24-29, 2002. Three vehicles were used – GAZ-66, UAZ-469 and Niva. The survey was conducted by 10 fieldworkers and coordinator (rangers of Borisovskoe Plateau Zakaznik and Barsovy Zakaznik, scientists from PIG and IBS FEBRAS – D.G. Pikunov, I.G. Nikolaev, V.V. Getmanov, I.V. Seredkin, A.I. Belov, S.V. Skvorchinsky, V.I. Barannikov, Rybalko, Vasiliev, I.V. Morozov).

2nd survey was conducted on February 5-15, 2003. It took more days to conduct the 2nd survey because routes were covered during sweep leopard survey. Usually the 2nd survey is conducted in shorter time – during 5-6 days.

In our opinion, the best time for conducting the 1st survey in Borisovskoe Plateau is the middle of December, better after snowfall. It is necessary to take into account that snow cover in this territory is usually insufficient in comparison with other territories of Primorye, especially in November and December. Therefore, the 1st survey should be conducted immediately after first heavy snowfall. The 2nd survey is better to conduct no later than mid-February, because this time thaws are usual and southern slopes become free of snow that makes difficult counting and measuring tracks.

As in previous years 14 survey routes were traveled with total length of 220 km. Survey routes ##1, 2, 3, 5, 8, 9, 10 were traveled on foot, routes ## 4, 7, 11, 12, 13 were covered by vehicle and routes ## 6 (M. Elduga) and 14 (Shufan) were covered partly by vehicle and on foot as in previous years.

During the 1st survey snow situation was favorable enough. Snow cover in eastern part of model unit or in lower river basins was not deep and did not exceed 3-10 cm. In western part of model unit (upper river basins) snow depth varies from 20 to 30 cm (see Table 3). Last heavy snowfall before the 1st survey happened on December 20, 2002. The 2nd survey was started 5 days after heavy snowfall. Therefore both surveys were conducted in favorable snow conditions, i.e. 4-6 days after heavy snowfalls. During the 1st and 2nd surveys in Borisovskoe Plateau there were no heavy snowfalls and work was done continuously.

Problems, which become more and more noticeable during all surveys, are the following:

1. Some survey routes are too long. Some of them are dead-end and fieldworker ran out of daylight before he could travel there and back. It is not enough time for him to travel along the route without haste and do careful measurements of predator tracks. Careful measuring of tiger and leopard tracks is very important part of monitoring work. Of course fieldworker tries to cover the route in daylight because it is easier and more safe. And if route length is 15 km and even 20 km (as it was originally established) and if such a route is dead-end (i.e. fieldworker should travel there and back) then he does not have enough time to do careful measurements of tracks. Such routes should be divided into two routes and they should be traveled from both ends if possible.

Survey routes, which should be divided into two next winter, are the following:

- # 6 – Malaya Elduga, 23-24 km long (route # 6.1 – up to confluence Kabarginskiy-Pryamoy creek, route # 6.2 – from confluence to upper Kabarginskiy creek);
- # 9 – Vtoraya Rechka, 24 km long (route # 9.1 – from lower reaches to mouth of Petrischenskiy creek, route # 9.2 – from timber-carrying road along Razdolnenskiy creek through upper Vtoraya Rechka to mouth of Petrischenskiy creek);
- # 10 – Pervaya Rechka, 20 km long (route # 10.1 – from lower reaches to Vodopadny creek, route # 10.2 – from Shufan timber-carrying road through upper Pervaya Rechka to Vodopadny creek mouth);
- # 14 – Shufan-upper (dead-end), 24 km long (route # 14.1 – from mouth of M. Shufan river to Koreiskiy creek, route # 14.2 – from Koreiskiy creek to KSP and back).

2. Each route should be covered by two fieldworkers. On routes covered by vehicle should be two people (driver and fieldworker) and routes covered on foot should be investigated by two fieldworkers. It is necessary because of safety measures. Moreover in severe winters in Borisovskoe Plateau unprovoked attacks of predators on people took place.

3. Fieldworkers should have either rifle (and to get special permission in appropriate organization) or other self-defense gear to protect himself from predators. Additionally coordinator should provide first-aid sets to fieldworkers and make sure that they have it during traveling along survey routes.

4. GPS are needed for each model unit. Fieldworkers will use them to determine the location of encountered predator tracks and in extreme case their own location. It will also allow determining coordinates of route traveled and places of ungulate concentrations.

5. It is necessary to have additional funds to travel some routes repeatedly and to cover them if possible to register predator and ungulate tracks. It is some kind of follow-up action to make sure the route was traveled and to obtain additional information about animal numbers over time.

Status of predator and ungulate populations

1. Tiger numbers in model unit increased nearly 1.5-2 times in comparison with previous year (contrary to our assumption). As was ascertained during the sweep survey tiger numbers increased in the whole territory of SWP. The reasons of the increase are not clear enough. In our opinion, it is not a natural growth of population although this reason may not be excluded completely. We think that suitable and especially good habitats (with high ungulate densities and low human disturbance) are shrinking and predators have to concentrate in confined area. It creates the illusion of high tiger density. In some confined areas tigers stay for a long time and leave numerous tracks and even experienced fieldworkers cannot identify them properly. Other areas are not visited by predators for a long time. Usually such areas are plateaus covered with deep snow with secondary oak forests, which ungulates leave, especially when snow cover is deep.

According to our calculations based on tiger track locations and measurements in winter 2002-2003 6-7 tigers inhabited the area of 120,000 ha. Within Borisovskoe Plateau model unit on 14 survey routes repeatedly covered during winter 30-35% of total tiger population residing in SWP was registered.

2. Significant increase of wolf numbers (or feral dogs, that is less possible) was observed in model unit. A lot of wolf tracks were registered during the survey in December (see Table 3a and 3b). When tiger numbers increased in model unit wolves disappeared, that was confirmed by comparison of data obtained during the 1st and the 2nd surveys. In December wolf tracks were found

on 10 routes, in February – only on one route (lower reaches of B. Elduga river).

3. After winter 2001-2002 with deep snow cover roe deer and young sika deer mortality rate was very high. During the 1st survey roe deer tracks were not found on most routes. In February roe deer was found, probably they migrated from Suifuno-Khankaiskaya plain, where snow cover was up to 100-120 cm deep. It is obvious that most part of local roe deer population in Borisovskoe Plateau died last winter because of deep snow. Those who survived moved down to densely populated lower reaches of rivers. Migrant roe deer is probably different subspecies, so-called “field roe deer” with smaller morphological parameters.

4. Musk deer numbers is still decreasing. Probably this species will extinct in SWP in near future.

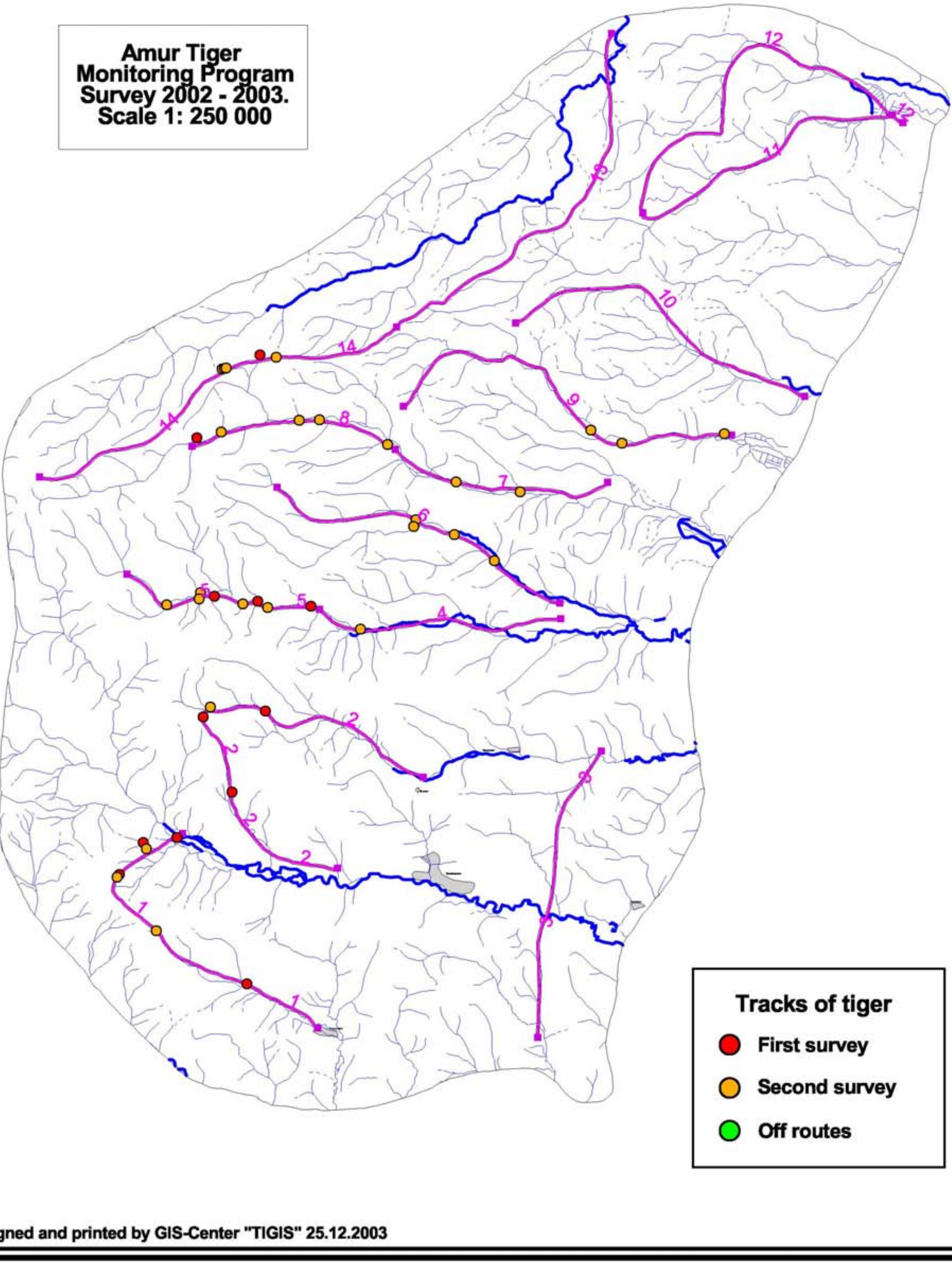
5. Sika deer – despite high mortality rate, which was observed last winter, the number of female deer is enough to provide normal abundance of sika deer, which is sufficient for hunting as well.

6. The situation with wild boar is good enough. Herds consisted of 20-30 individuals were observed. Probably the number of this valuable species is increasing.

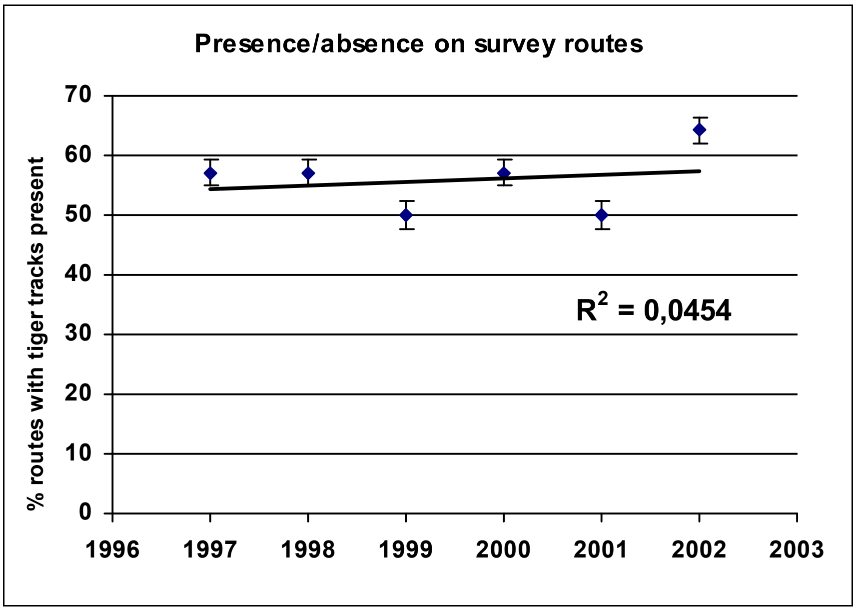
Thus, the results of two surveys indicate that the situation with tiger, leopard and ungulate populations seems to be good. The only issue of concern is the increase of wolf numbers, which was not observed for the last 30 years.

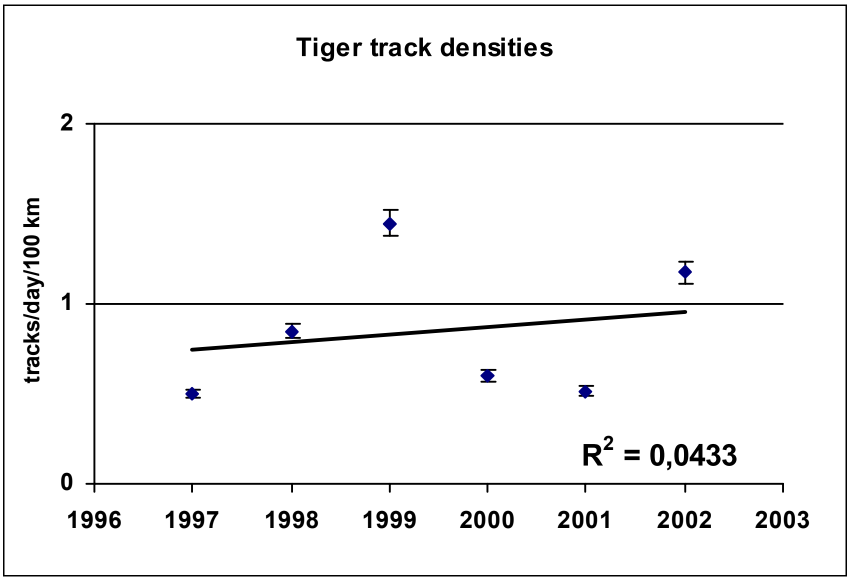
Predators and ungulates concentrated in confined area in upper river basins, i.e. within protected areas – first of all in Borisovskoe Plateau and in Barsovy Zakaznik to a lesser extent. In hunting leases (including Nezhinskoe hunting lease) the number of animals listed in the Red Book and ungulates is still much more less despite ban on hunting wild ungulates, which was put on last winter. The supposition that the area of suitable habitat for predators and ungulates is shrinking with each coming year proved to be correct. It is the result of development of remote areas, which were not accessible earlier and therefore represented ‘no hunting’ zones. Animals have to concentrate in good habitats. Based on this we think that it is necessary to prohibit hunting all animal species in the territory to the right of the road from Terekhovka to Kraskino. It will be the most important condition for conservation of unique fauna of Southwest Primorye.

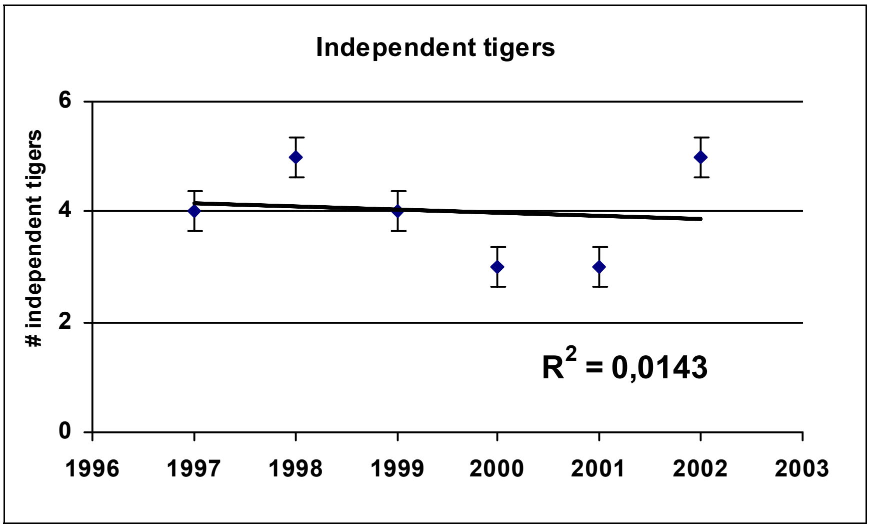
Model unit "Borisovskoe plato"



Designed and printed by GIS-Center "TIGIS" 25.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,0454


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,0433

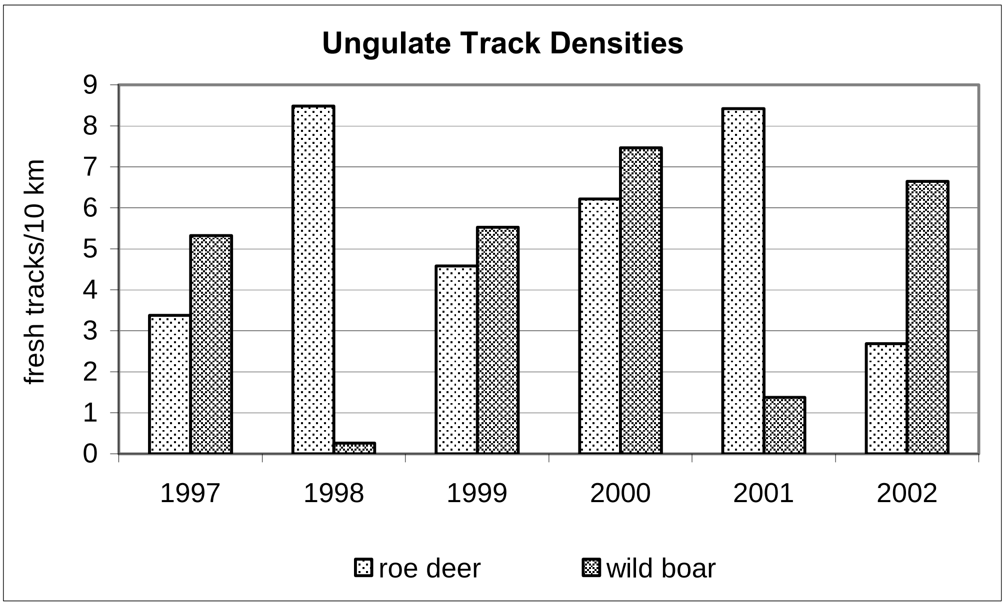

Independent tigers
independent tigers
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,0143

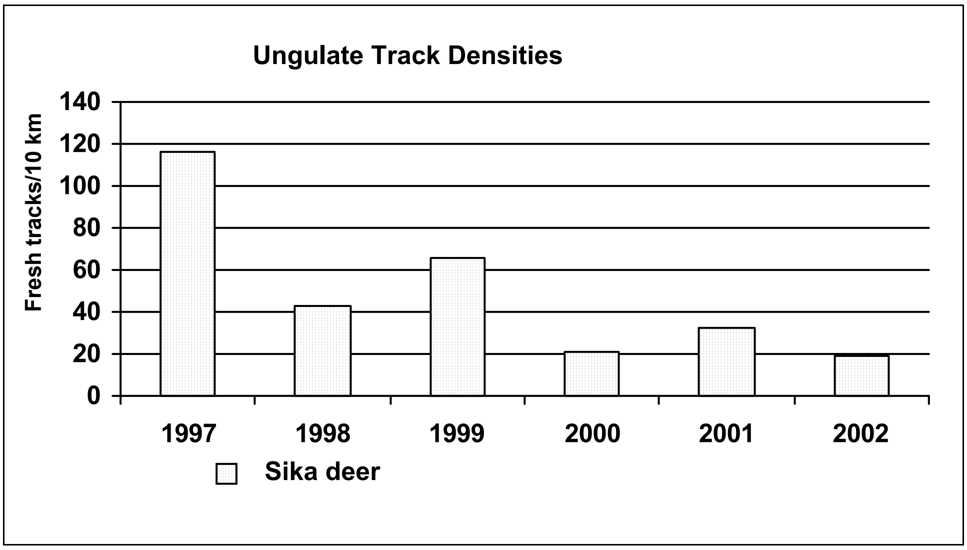
Number of tigers, by age class and sex (for adults only) in “Borisovskoe Plateau” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	2	0	1	1	0	3	3	4
1998	1	1	1	2	1	1	3	4	5
1999	1	2	0	0	1	0	3	3	4
2000	1	2	0	0	1	0	3	3	4
2001	1	1	1	0	0	1	3	4	4
2002	1	2	0	2	2	0	3	3	5

Mean track density (tracks less than 24 hours) of ungulates in “Borisovskoe Plateau” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	14	0.02	0.1	3.38	7.97	116.29	206.68	5.32	
1998	14	0	0	8.48	18.95	42.87	61.13	0.26	0.88
1999	14	0	0	4.58	8.37	65.74	113.1	5.53	8.13
2000	14	0	0	6.22	8.31	20.81	19.19	7.47	17.03
2001	14	0	0	8.42	18.32	32.51	66.53	1.38	4.54
2002	14	0	0	2.69	3.79	18.58	28.56	6.64	10.79
Total mean		0	0.02	5.63	10.95	49.47	82.53	18.73	39.11





Ungulate Track Densities
Fresh tracks/10 km
140
120
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
Sika deer

SANDAGOU

Southeast Primorsky Krai

Report on results of Amur tiger monitoring program in Sandagou monitoring unit in winter 2002-2003
Coordinator - V.V. Aramilev, Institute for Sustainable Use of Natural Resources

In Sandagou model unit surveys were conducted on January 11-12, 2003 and February 8-9, 2003. All survey routes were covered completely during two days of each survey. Then several routes were traveled repeatedly to control data collection.

Weather conditions this year were typical for this area. First snow fell in the end of October but melted quickly. Until the middle of December, snow cover was not permanent and we could not conduct the 1st survey in December. Heavy snowfall happened on January 4, 2003. In a week after snowfall snow cover was 50-60 cm deep on passes and 30-40 cm deep in valleys. In adjacent Chuguevsky Raion snowfall, which happened in October, resulted in snow cover up to 70-90 cm deep and threatened the survival of ungulates through this winter. Subsequent snowfalls aggravated the situation. In model unit the situation was different. High density of wild boars was observed in model unit in October and November. By the beginning of the 1st survey wild boars had spread across the whole territory of model unit with moderate density. No migrations of red deer and sika deer were observed. Roe deer moved from areas with deep snow to river valleys. Concentration of roe deer was registered in Mineralnaya river valley. By the time of the 2nd survey the situation had not changed significantly. Snow depth decreased slightly both on passes and in river valleys. Steep southern slopes were partly free of snow. Ungulates were concentrated in river valleys as in January. Densities of ungulates were the same as in previous year.

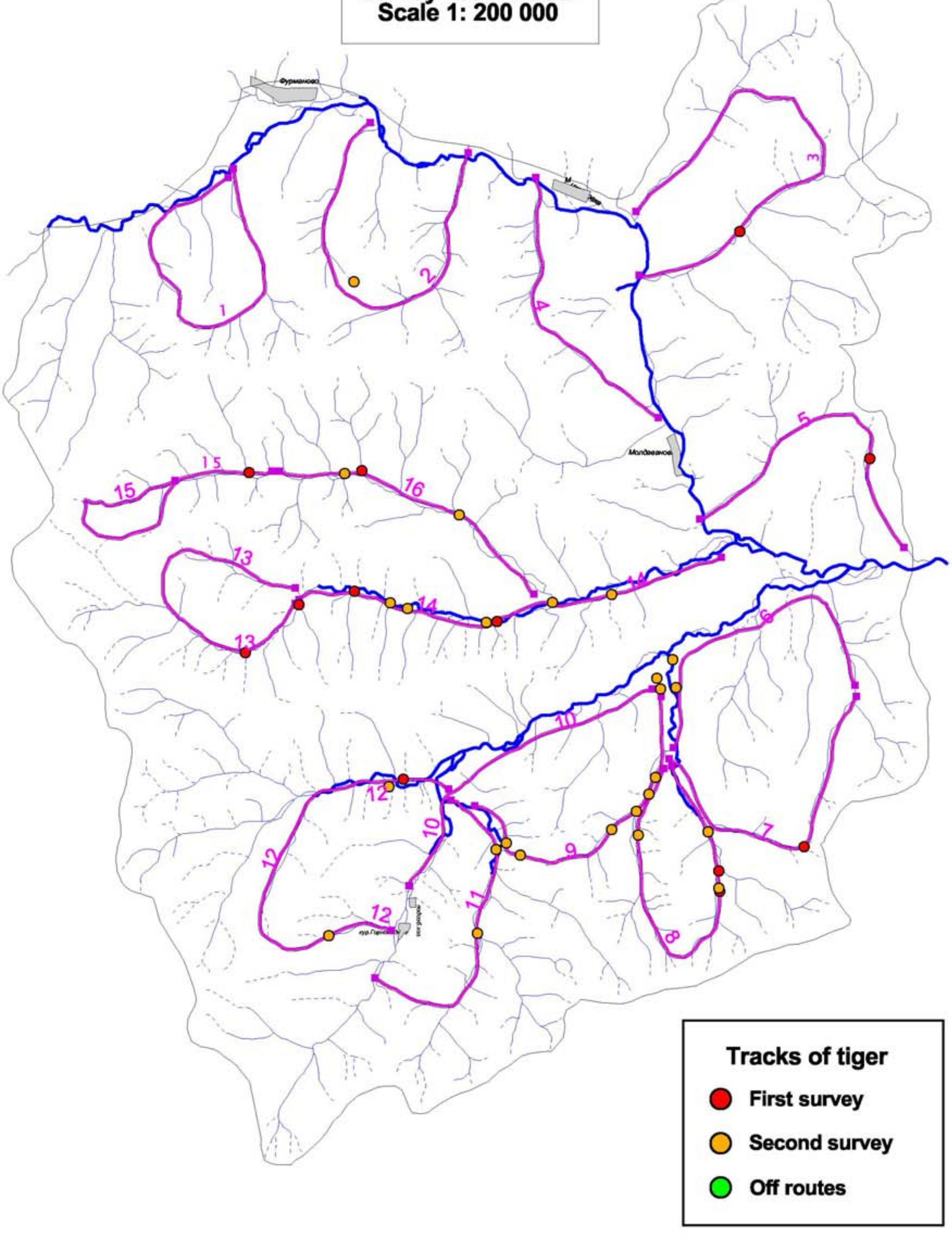
Tiger distribution this winter was specific. During the 1st survey tiger tracks were not numerous, though it was conducted 7-8 days after snowfall. In January, tiger tracks were found in central and southern parts of model unit, in February – in southwest and central parts. The same situation took place 4 years ago. During the 1st survey 5 tigers were identified, in February – 7 tigers (plus 2 adult males). According to interviews and tracks found one female was in rut period. Females with cubs born this year were not found. But the presence of 4 individuals of unknown sex and age suggests that successful reproduction took place last year. Tiger tracks were found in northern part of model unit, where they were very rare.

Last winter concentration of ungulates was observed in the most protected areas of model unit: Mysovka creek, Berezovy creek and Forelnaya river areas. The highest tiger density was registered in the same areas.

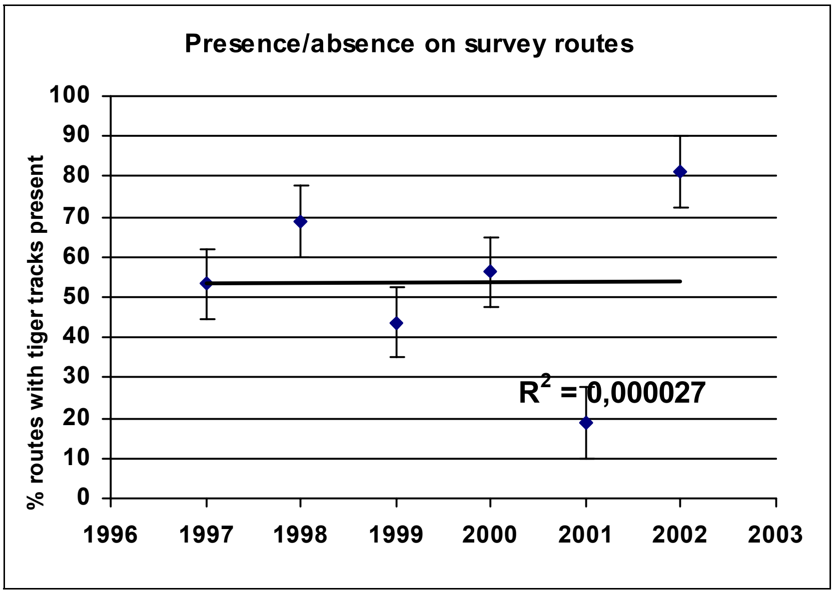
Significant changes of anthropogenic factors were not registered. Human population and the number of cattle are the same as in previous years. No heavy fires happened this year. Moderate commercial logging took place in northern part of the model unit. Total logging area is 310 ha. Hunting management is conducted at the same level.

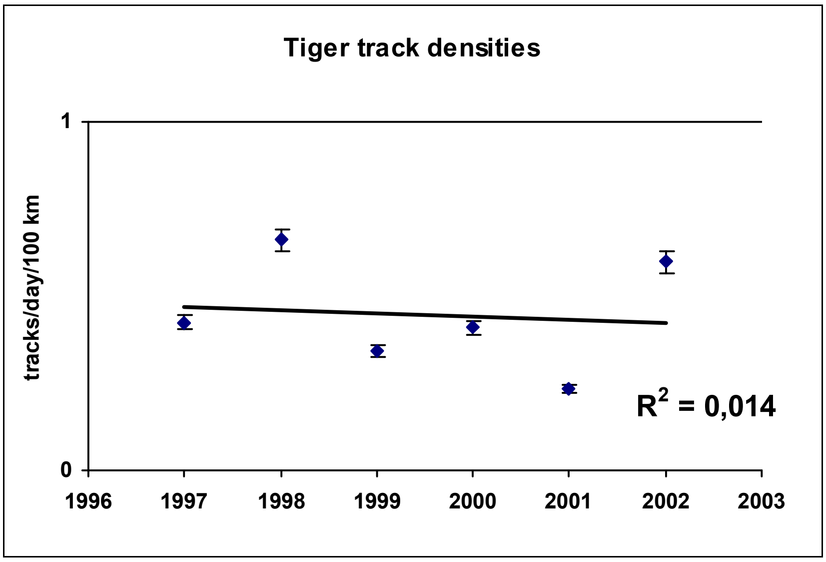
Model unit "Sandago"

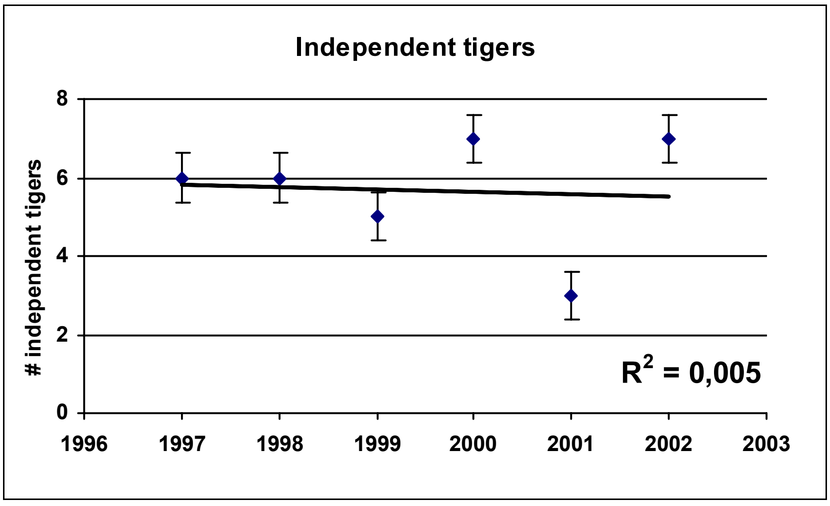
Amur Tiger
Monitoring Program
Survey 2002 - 2003.
Scale 1: 200 000



Designed and printed by GIS-Center "TIGIS" 26.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
100
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,000027


Tiger track densities
tracks/day/100 km
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,014

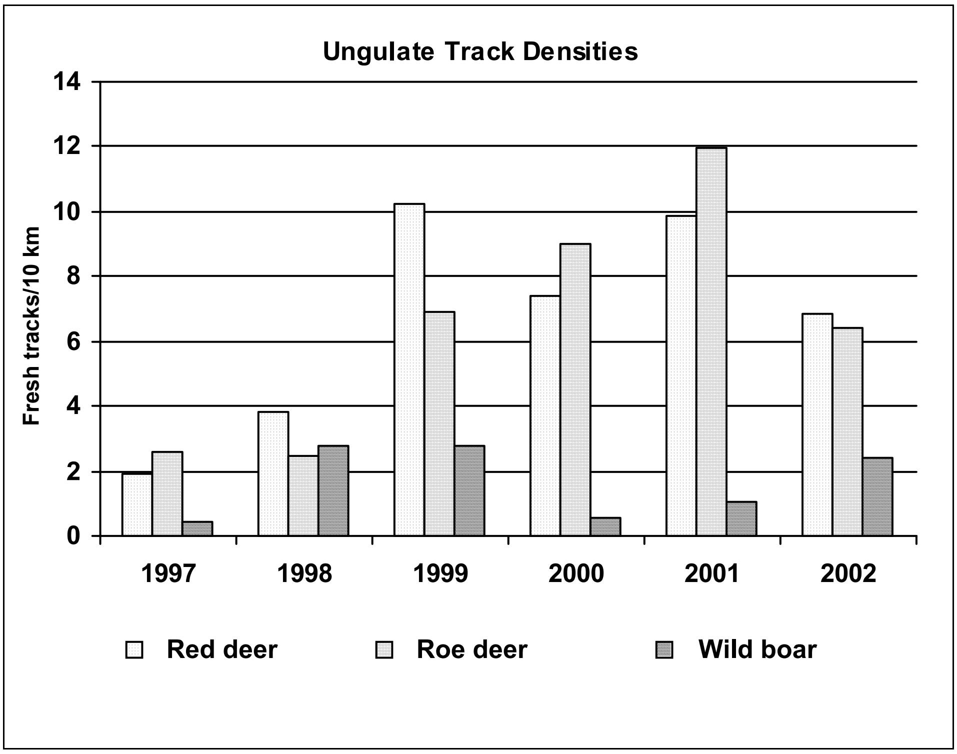

Independent tigers
independent tigers
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,005

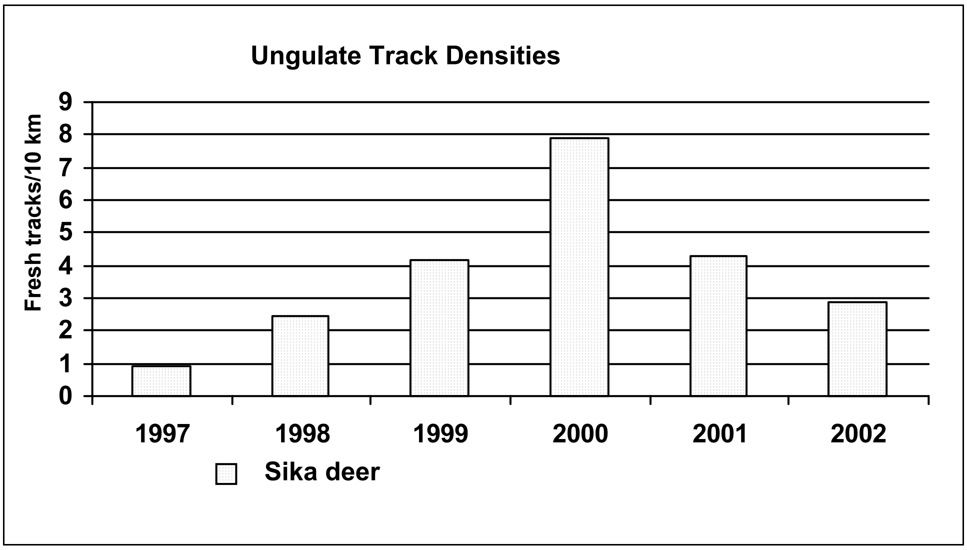
Number of tigers, by age class and sex (for adults only) in "Sandagou" Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	2	0	0	4	0	3	3	7
1998	0	1	5	0	1	5	6	11	12
1999	1	1	3	0	0	3	5	8	8
2000	2	1	3	1	0	3	6	9	9
2001	0	0	0	0	2	0	0	0	2
2002	2	1	3	1	0	3	6	9	9

Mean track density (tracks less than 24 hours) of ungulates in "Sandagou" Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	16	1.93	3.19	2.58	3.07	0.94	1.92	0.43	0.96
1998	16	3.84	4.02	2.44	3.19	2.46	4.2	2.76	4.43
1999	16	10.22	12.1	6.91	8.25	4.19	6.07	2.77	5.97
2000	16	7.41	10.41	8.98	11.44	7.91	19.32	0.54	1.49
2001	16	9.87	14.21	11.94	9.8	4.27	7.04	1.04	4.05
2002	16	6.87	8.55	6.39	9.78	2.86	5.57	2.42	3.35
Total mean		6.69	8.75	6.54	7.59	3.77	7.35	1.66	3.37




Ungulate Track Densities
Fresh tracks/10 km
9
8
7
6
5
4
3
2
1
0
1997
1998
1999
2000
2001
2002
Sika deer

SINYAYA

Central Primorsky Krai

Report on results of Amur tiger monitoring program in Sinyaya monitoring unit in winter 2002-2003

P.V. Fomenko, WWF-RFE Program Coordinator

Surveys were conducted in January and February, 2003. We could not conduct the 1st survey in December, 2002 because of weather conditions. In general, the work was organized without any financial or other problems. Fieldworkers were the same as in previous years and it allowed to improve data collection and field survey.

Weather conditions in winter 2003 were critical both for animals, especially ungulates, and for the organization of surveys. After heavy snowfall, which happened in October-November, 2002, trees along survey routes fell and routes were not passable for 4WD vehicles and snowmobiles. Considerable efforts were needed to clear away the survey routes. This year weather conditions were critical for ungulates because of deep and very dense snow, which then turned to icy crust (snowfall was followed by heavy rain).

In study area (and in central part of Primorye – Chuguevsky, Yakovlevsky, Anuchinsky, Oktyabrsky, Chernigovsky, Kirovsky, Lesozavodsky and Kavalerovsky Raions) roe deer population suffered from deep snow and lack of forage most of all. Ungulates died from starvation and were poached in the fields and near the roads, where they concentrated after the first heavy snowfall. According to our estimates during this winter with deep snow cover nearly 100% of young roe deer (born last year) died in Sinyaya model unit as well as 20% of adult animals (without taking the number of poached animals into consideration).

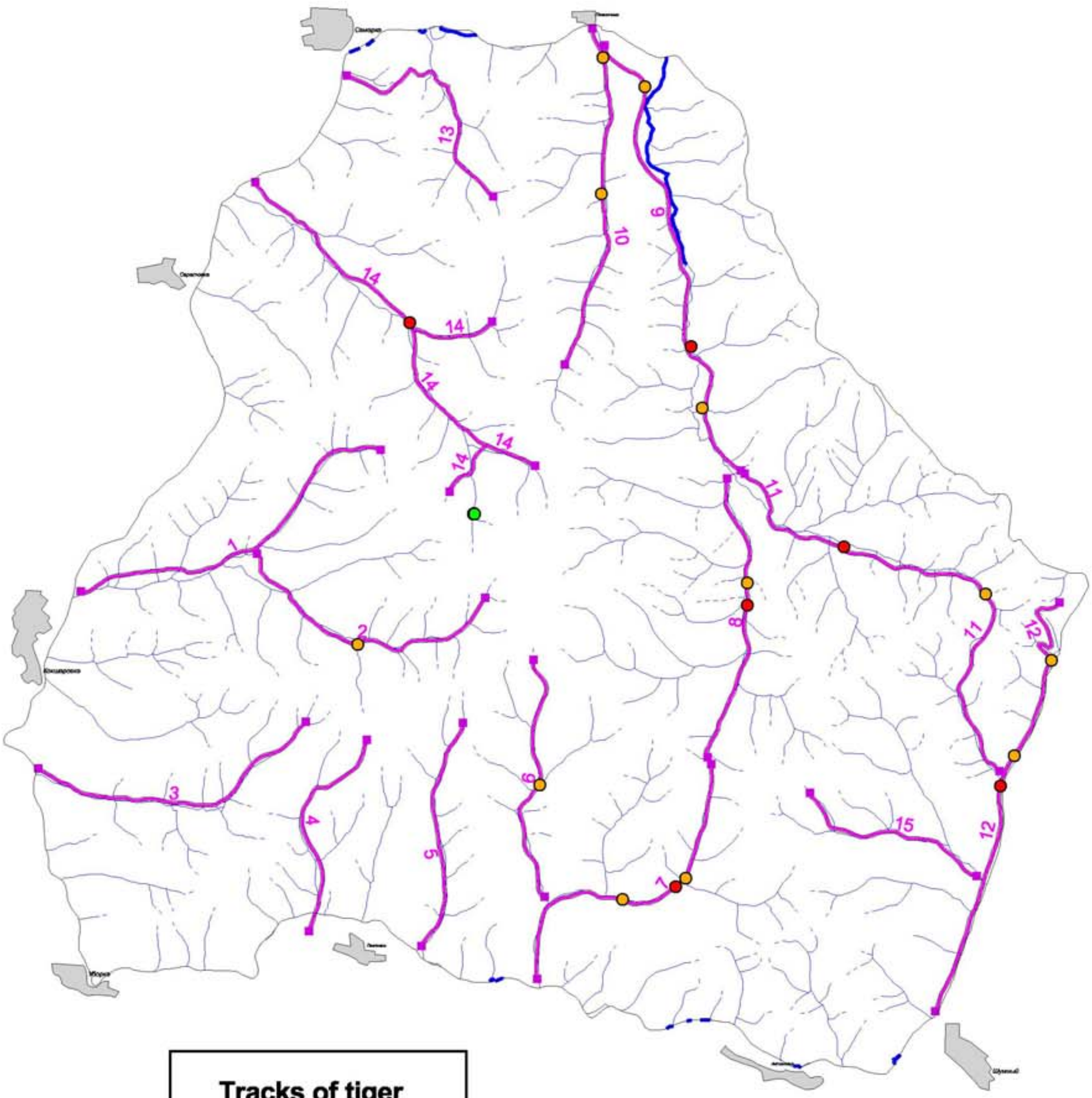
The situation with wild boar and red deer was slightly different. Rich harvest of acorns and pine cones in local areas caused concentration of wild boar in these areas. Red deer concentrated in valleys (flood-plains), on steep slopes and in places, where horse-tail was abundant. In Sinyaya model unit only insignificant number of young red deer died this winter (because of deep snow) and the main pressure upon red deer population was put by hunters.

According to our estimates, tiger population in study area is stable, despite the fact that no cubs were registered during surveys. Cubs were found before or after surveys. Tiger deaths were not registered.

Generally, the situation in Sinyaya model unit could be estimated as stable, taking into consideration all factors, including use of nature resources – logging, hunting, collecting non-timber forest products and fires.

Model unit "Sineya"

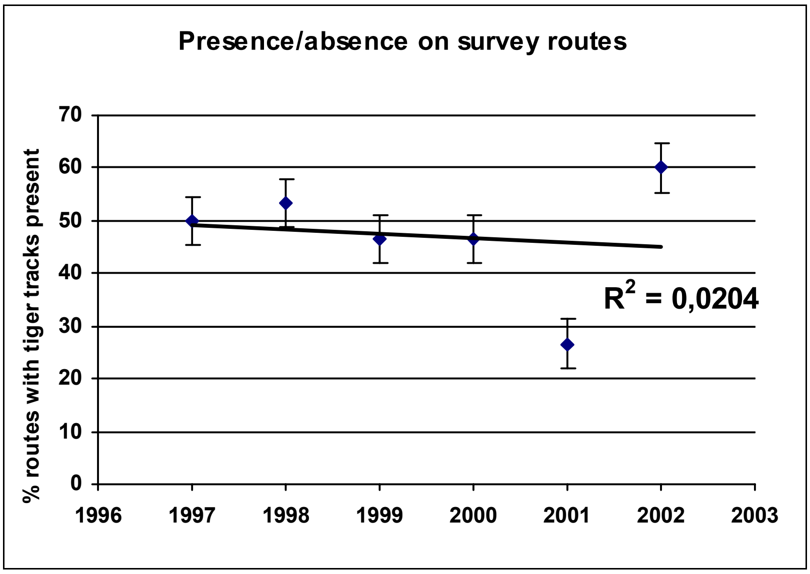
Amur Tiger
Monitoring Program
Survey 2002 - 2003.
Scale 1: 250 000

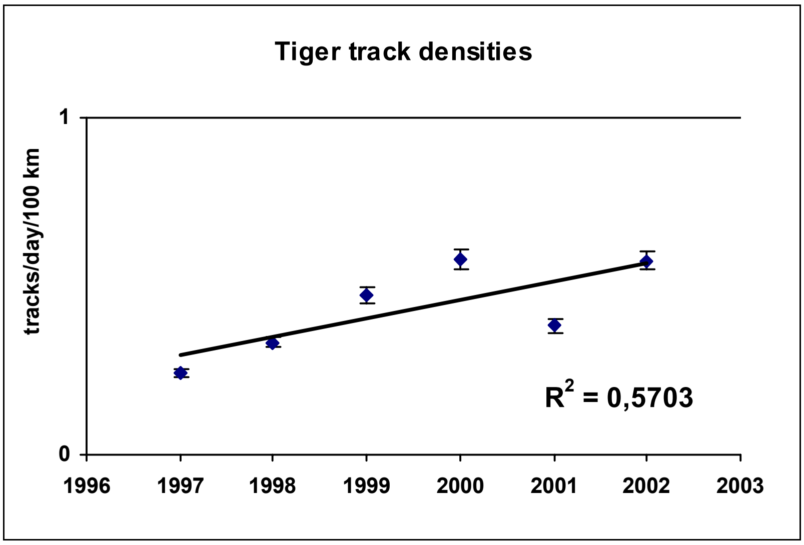


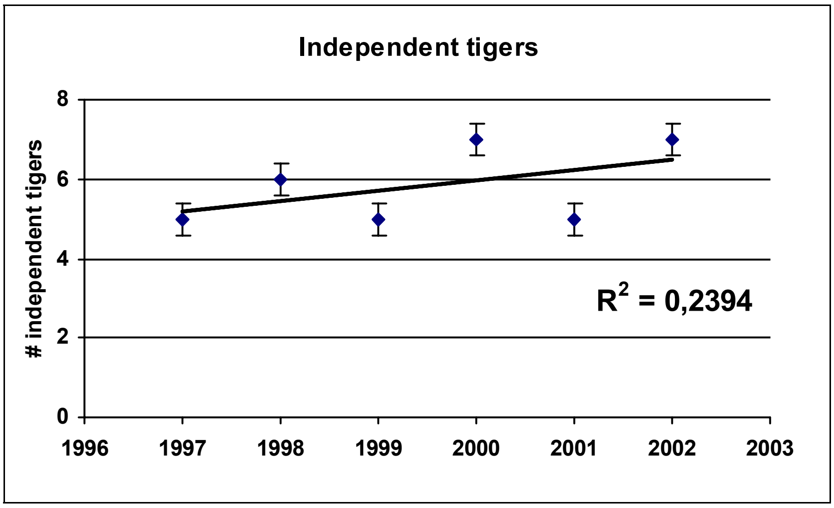
Tracks of tiger

- **First survey**
- **Second survey**
- **Off routes**

Designed and printed by GIS-Center "TIGIS" 26.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,0204


Tiger track densities
tracks/day/100 km
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,5703

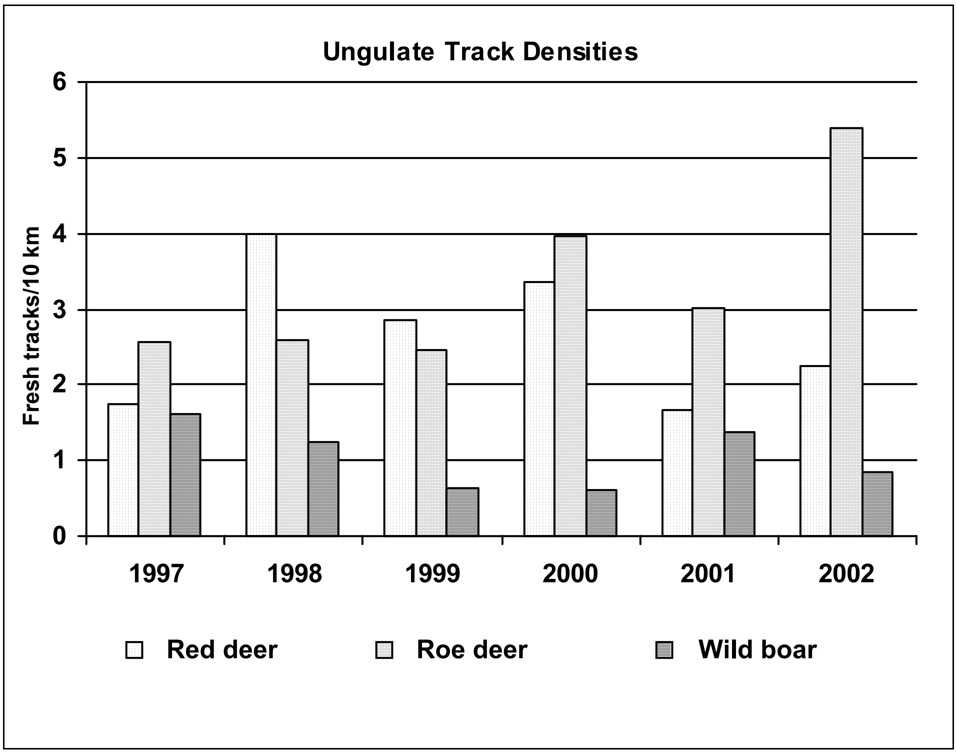

Independent tigers
independent tigers
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,2394

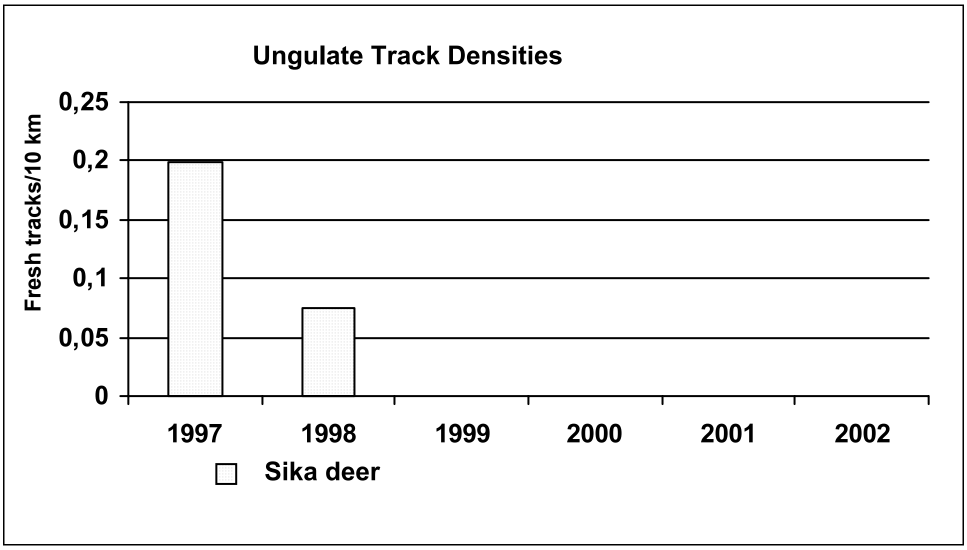
Number of tigers, by age class and sex (for adults only) in “Sinyaya” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	0	1	2	1	2	2	4	5
1998	1	2	1	1	0	2	4	6	6
1999	2	2	0	1	1	0	4	4	5
2000	2	3	0	1	3	1	5	6	9
2001	3	1	0	1	3	0	4	4	7
2002	3	4	0	0	0	0	7	7	7

Mean track density (tracks less than 24 hours) of ungulates in “Sinyaya” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	15	1.74	1.86	2.57	2.83	0.2	1.08	1.61	3.19
1998	15	4	4.2	2.59	2.59	0.08	0.31	1.23	2.06
1999	15	2.86	3.79	2.45	2.49	0	0	0.63	1.45
2000	15	3.35	2.65	3.96	4.09	0	0	0.6	1.81
2001	15	1.67	2.2	3.01	3.25	0	0	1.39	2.84
2002	15	2.25	1.88	5.4	3.7	0	0	0.86	1.43
Total mean		2.64	2.76	3.33	3.16	0.05	0.23	1.05	2.13




Ungulate Track Densities
Fresh tracks/10 km
0,25
0,2
0,15
0,1
0,05
0
1997
1998
1999
2000
2001
2002
Sika deer

IMAN

Central Primorsky Krai

Report on results of Amur tiger monitoring program in Iman monitoring unit in 2002-2003 winter

Coordinator - I.G. Nikolaev, Institute of Biology and Soils, Far Eastern Branch Russian Academy of Sciences

Iman model unit is located in Malinovka river basin (Dalnerechensky Raion, Primorski Krai). The territory of model unit (140,000 ha) includes upper basin of Orekhovka river and its tributary - Gornaya river. The border of the model unit lies mostly on divides of these rivers basins and only in the west it runs through valleys of Orekhovka and Gornaya rivers, crossing them near cross-road that leads to Polyana and Martynova Polyana villages.

The number of routes on model unit, their numeration and location are the same as in previous years.

Survey routes were covered on December 1-3, 2002 and in March 5-7, 2003.

In December total length of routes traveled by vehicle is 131 km, on foot - 67. In March total length of routes traveled by vehicle is 115 km, on foot - 83 km. Discrepancy between types of travel during the first and the second counts was caused (as in past years) by big difference between snow cover depth during the first and the second surveys. In December minimum and maximum snow depths in open areas were 40 cm and 60 cm correspondingly; in March - 52 cm and 84 cm correspondingly. Due to this fact in the second half of winter several routes, which were not passable by vehicle, were traveled on skies.

Last snowfall before survey in December happened on November 27 and snowfall before survey in March - on February 10. Therefore, it had not been snowing for 3 days before first survey and for 22 days before the second survey.

This year wintering conditions were extremely hard both for tigers and ungulates. Stable snow cover formed in October, a month earlier than usual. Heavy snowfalls alternated with clear frosty days, thaws, sometimes with rain and all these resulted in stratified firm icy crust over snow. In such situation it was difficult for ungulates not only to move but also to find forage. Their movements became less active. Animals virtually stay on the spot. Home ranges of red deer and roe deer shrank to several hundreds of meters in diameter. Adult wild boars, which were seen in the end of winter, were emaciated, and hunters saw emaciated piglets died from starvation in adjacent territories.

As in previous years sharp predator-prey imbalance took place this winter. Among tiger prey species first of all it concerns wild boar - its density has been remaining at the lowest level for the past several years. Wild boar numbers decreased even in comparison with previous year. In December wild boar track encounter rate was 1.8 per 10 km of survey routes, whereas in December, 2001 it was more than twice higher. Red deer numbers did not change, and roe deer numbers slightly increased and population status of these two species can be estimated as satisfactory.

As in previous years, ungulates and tigers were distributed across areas in the middle reaches of Orekhovka and Gornaya rivers.

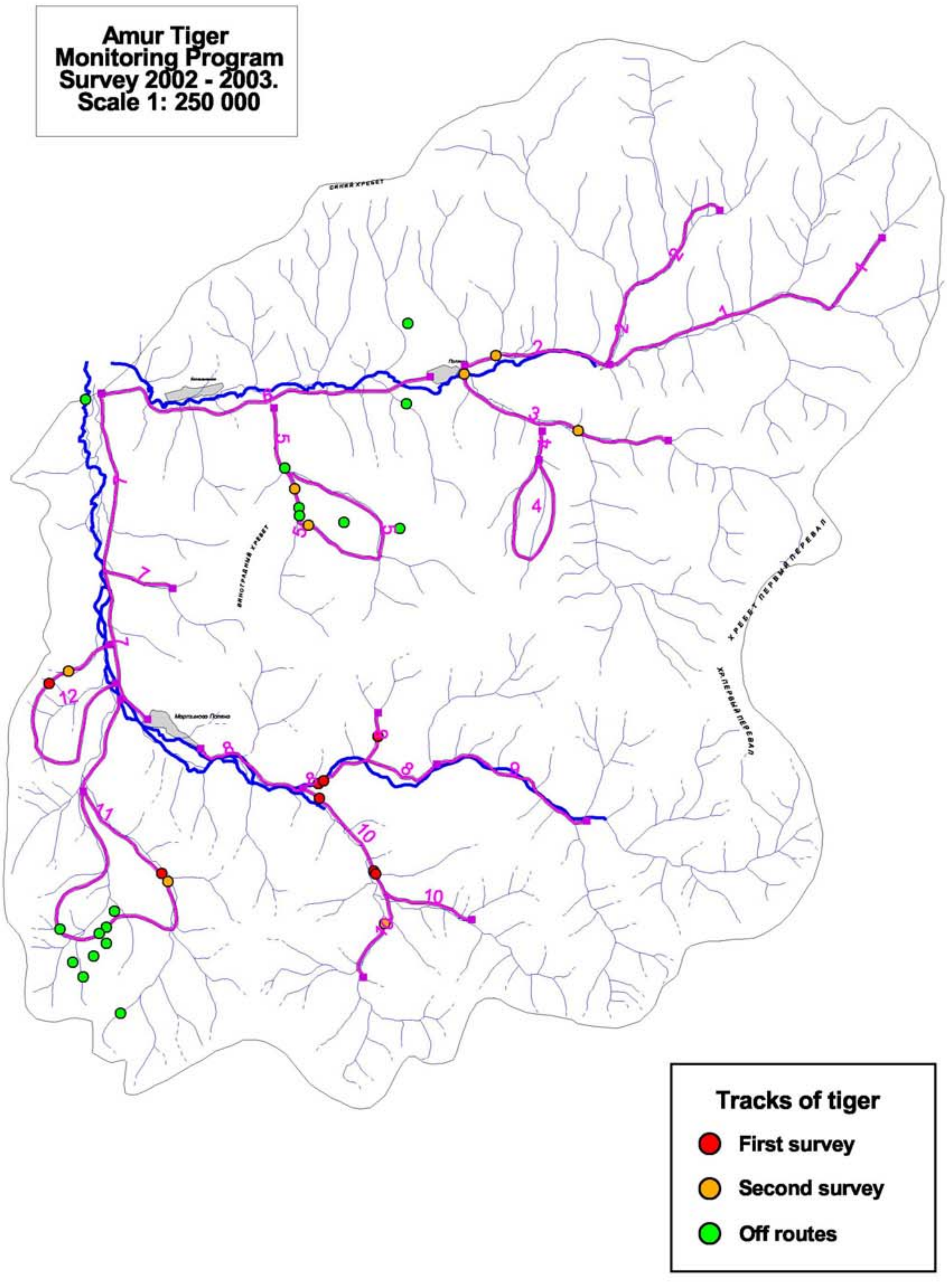
This year slight decrease of tiger numbers was registered in our model unit. For the first time tiger tracks were not found during the survey in December in Orekhovka river basin. According to interviews with local people one tiger was registered here in early fall. One of the reasons of tiger absence in this area are the deaths of two female tigers. One female was officially shot on December 2, 2000 after she attacked a man in upper reaches of Orekhovka river. Some time later the second female was poached at the same place. Tiger cubs were also absent this winter.

The second (after prey species status) important negative factor is human disturbance. The role of this factor has increased due to the more intensive logging. Logging activity increased mostly due to different industrialists and illegal logging. This factor affects females with cubs most of all. They usually left the territory where logging begins.

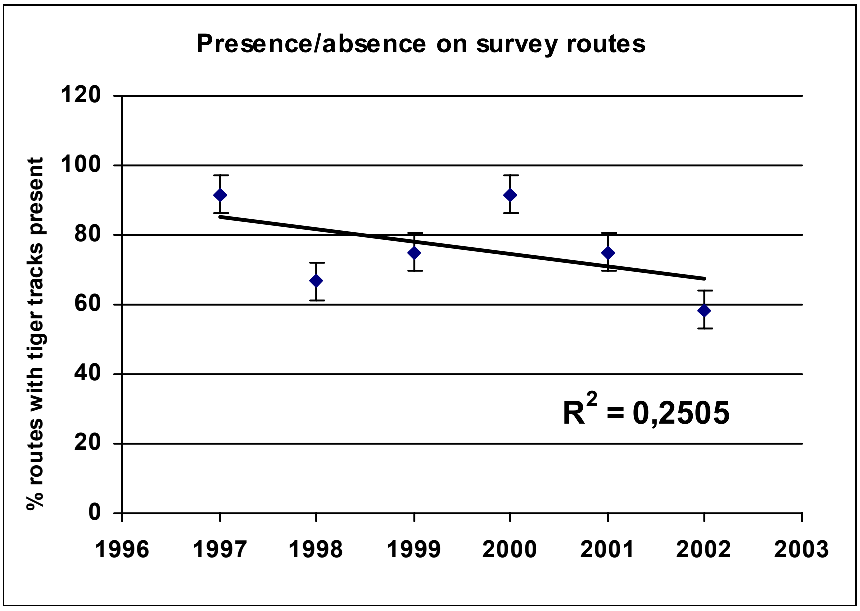
Although during this winter season habitat conditions within model unit are estimated as unfavorable, nevertheless tiger density remains satisfactory and is 2.9 adult individuals per 1,000 km^2.

Habitat conditions on model unit still remain at the level suitable for tiger survival in the near future.

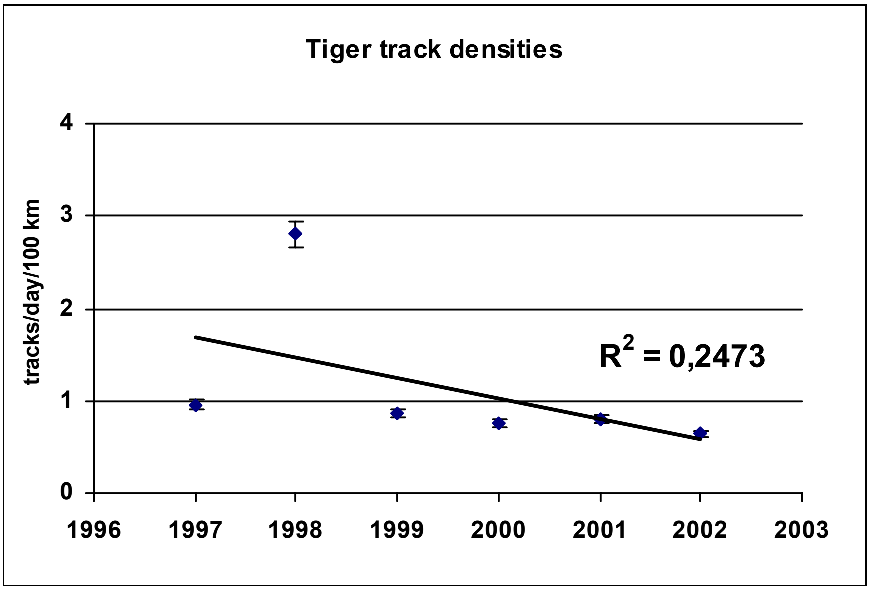
Model unit "Iman"



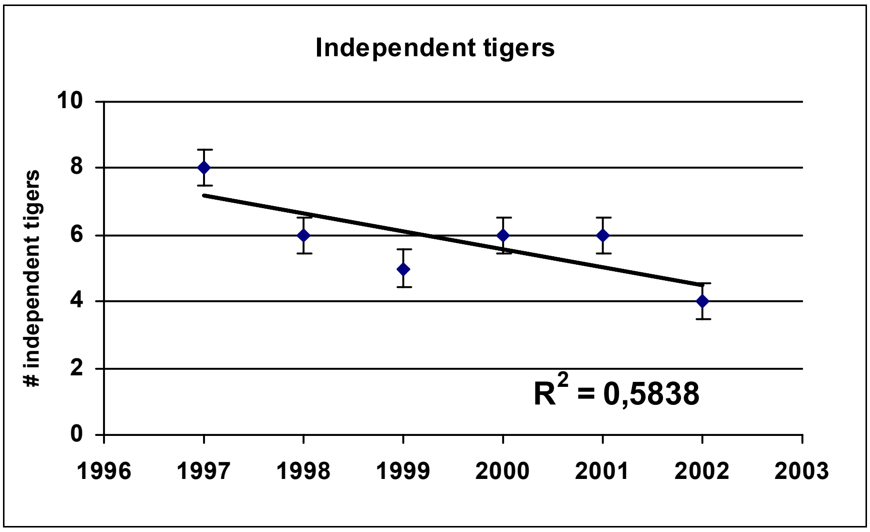
Designed and printed by GIS-Center "TIGIS" 25.12.2003



Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,2505



Tiger track densities
tracks/day/100 km
4
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,2473



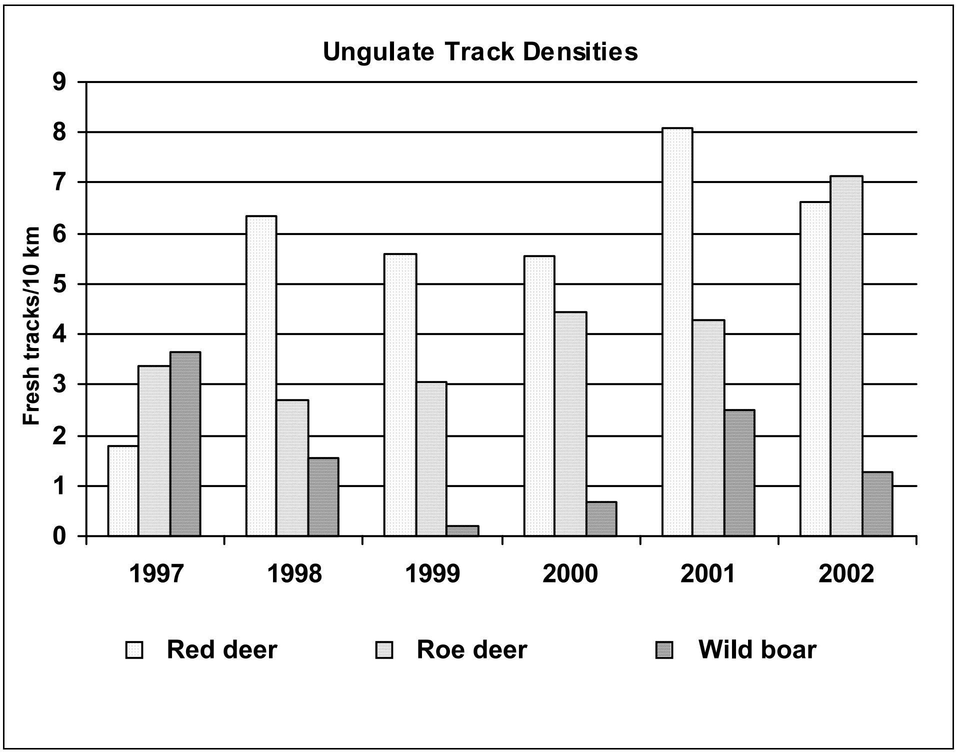
Independent tigers
independent tigers
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,5838

Number of tigers, by age class and sex (for adults only) in "Iman" Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	3	1	1	2	0	2	5	7	7
1998	3	2	0	1	2	0	5	5	7
1999	2	1	1	1	2	1	4	5	7
2000	2	3	0	1	2	0	5	5	7
2001	3	2	0	1	1	0	5	5	6
2002	2	2	0	0	0	0	4	4	4

Mean track density (tracks less than 24 hours) of ungulates in "Iman" Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	12	1.79	3.06	3.38	5.55	0	0	3.63	5.23
1998	12	6.33	7.91	2.68	2.63	0	0	1.55	3.15
1999	12	5.58	7.67	3.05	5.47	0	0	0.2	0.6
2000	12	5.56	5.61	4.45	6.98	0	0	0.66	2.89
2001	12	8.1	6.49	4.29	7.68	0	0	2.51	4.36
2002	12	6.62	10.35	7.13	12.33	0	0	1.26	1.81
Total mean		5.66	6.85	4.16	6.77	0	0	1.63	3.01



BIKIN
Central Sikhote-Alin, Northern Primorsky Krai

Report on results of Amur tiger monitoring program in Bikin monitoring unit in winter 2002-2003

Coordinator - D.G. Pikunov, Pacific Institute of Geography, Far Eastern Branch Russian Academy of Sciences

The first survey in Bikin model unit was conducted from January 6 through January 12, 2003. First routes were traveled on January 7 and 8, because on January 4 and 5 heavy snowfall took place in Bikin model unit and all animal tracks were covered with snow.

Usually the 1st survey can be conducted in Bikin model unit no earlier than in the beginning of January, because single road leading to this area is being made by local hunters on snowmobiles along frozen Bikin river. Usually hunters leave their hunting grounds on New Year's Eve and form the road along frozen Bikin river. In December there is no such road along the river and traveling along it is unsafe.

The work was done continuously because there were no heavy snowfalls in this period of time. The 2nd survey was conducted from March 1 through March 6, 2003, it was delayed because leopard monitoring was conducted in Southwest Primorye and was completed only by February 25, 2003.

The best time for conducting of the 2nd survey in Bikin model unit – February 10-20 of each year. It is important because exactly this time independently of average winter temperatures and snow depth there is well-trodden snowmobile road along the river and no ice mounds. Moving on ice mounds on loaded snowmobiles is difficult and even unsafe. The second important reason is the presence of professional hunters on their hunting units. They can and should provide the important information (including “additional information”) about the presence of tigers in different areas, their sex and age, about litters location, ungulates distribution and tiger deaths. Usually hunters leave their hunting units after February 20, soon after hunting season (on fur-bearers) is closed (on February 15).

As in previous years 16 survey routes were traveled in model unit, 2 of them along Bikin river and other 14 – along right and left Bikin tributaries.

Relatively detailed description of Bikin model unit was given in previous monitoring reports. We’ll remind only that in the west it is limited by new bridge across Bikin river and by main road from Khabarovsk to Nakhodka. With each coming year more people (fishermen, hunters, pickers of non-timber forest products, poachers and subpurchasers of different raw materials) use the road more and more intensively. This road crosses one of the most valuable tiger habitats in Bikin river basin. Tigers sometimes cross this road yet but do this more and more rarely with each coming year. Very likely that later when this road functions in corpore and crosses Sikhote-Alin mountains in one of the most beautiful forest territories it will attract many travelers and tourists and will be intensively used by people. It will be the serious barrier for all large animals and most of all for such large predators as tigers.

Survey routes were traveled as in previous years: routes ## 1, 2, 10, 11 were traveled by snowmobile. Other routes ## 3, 4, 6, 7, 9, 12, 13, 14, 15 and 16 were traveled on foot. Routes ## 5 and 8 were partly traveled on skies and partly by snowmobile. Total length of routes traveled by snowmobile is 70 km (determined with curvimeter on map 1: 100,000), on skies – about 120 km. Average length of the route traveled by snowmobile is 15 km, on skies – 11 km.

Survey conditions

1st survey. Snow situation was favorable for conducting the survey of tigers and ungulates. Average snow depth in the area was 45-55 cm, that is 1.5-2 times more than during the 1st survey last year. Heavy snowfall took place on January 4-5, 2003, i.e. when we came to Krasny Yar. On January 6, we arrived to model unit and first routes were traveled on January 7 and 8.

Heavy snowfalls in upper Bikin caused active migration of ungulates. Red deer and roe deer moved very actively, wild boar moved less actively. Ungulates concentrated mostly in flood-plain forests in Bikin river valley and to a lesser extent in its main tributaries valleys. This probably caused tiger migration and concentration in some areas of Bikin. As a result, tiger tracks were not found on some survey routes. However, on most routes the situation was generally the same as in previous year.

2nd survey. Snow situation became more difficult. Heavy snowfalls happened (the last one took place about 20 days before the survey). Snow settled greatly and partly was covered with icy crust. This made difficult movements of ungulates and tigers. It seemed that tigers unwillingly moved even within their home ranges. As a result numerous tiger tracks were found on some routes. In the other part of home range even in the presence of ungulate concentrations only old tiger tracks or no tracks were found.

The situation with ungulates was the same. Maximum concentrations of ungulates were observed in flood-plain forests of Bikin river valley. Here red deer and roe deer concentrated mostly near Bikin channels, avoiding the main riverbed, where snowmobile road was intensively used. This winter wild boars rarely moved down to the valley because they fed upon pine nuts, which were abundant in the most part of model unit. In such territories tigers moved along wild boar trails and stayed nearby wild boar herds for a long time. As a result some tigers were not registered. Predators preferred traveling along winter roads, snowmobile roads and ski-tracks (probably they do so in winters with deep snow). It seems that in such winters with deep snow when ungulates concentrate in confined areas tiger numbers can be underestimated because they do not move actively within their home ranges.

It is known that snow distribution significantly influences on distribution of ungulates and tigers. This difference is evident not only between years but also within one model unit. However snow depth is measured in different ways within model unit therefore this measurements sometimes gives distorted information about snow distribution across study area. According to Monitoring Instruction fieldworker measures snow depth at the start point, in the middle and in the end of survey route. In the Field Diary is not written if the route goes along river or creek or snow depth was measured on different slopes as well. Moreover, if a field worker covers the route bottom-up and coordinator is not informed about it then the information about snow distribution is incorrect. Finally, snow depth is measured on the route (in the forest), for which crown density is not noted. Only forest type is noted. As it is known, maximum crown density is close to 1.0 and minimum is close to 0.1-0.2. Therefore, independently of forest type the more crown density is (0.7-0.9) around the route the less snow depth is on the route (i.e. snow depth is in direct proportion to crown density). Therefore fieldworker should note crown density (in figures) in places, where snow depth was measured. Also it is important to write if survey route was traveled bottom-up or top-down (in unusual way for some reasons). This note should be done near the table, where snow distribution is showed.

No doubt not all information on tiger deaths is provided. This information is usually secret and hunters do not like to talk about it. Usually such information is given only generally. For example how many tigers are poached in Bikin river basin during the year? Usually hunters provide such information only for the previous years.

Status of ungulate populations

Red deer and roe deer numbers slightly increased.

According to the information given in the table, red deer numbers increased nearly twice, wild boar numbers slightly increased and roe deer numbers remained the same as in previous year. Probably it is connected with heavy precipitation in upper Bikin and Khor divide. Heavy snowfalls took place in late October that is unusually early for this area. Then snowfalls happened in November and even December. Red deer migrated actively, roe deer migrated to a lesser extent (probably because roe deer is not abundant in upper Bikin) and wild boars migrated a little. It seems like the situation with wild boar is becoming better, probably because of long-expected harvest of pine-cones and acorns in some confined areas.

The situation with ungulates in Bikin river basin, at least with red deer and wild boar, is unlikely to become worse. Large forested areas little by little become undeveloped due to difficult access. Such areas become specific reservations or “calm zones” for animals. Small part of ungulate populations is hunted and it positively affects ungulate numbers. Probably only roe deer numbers will decrease slightly because of deep snow, which is close to critical for this species.

Significant decrease of wild boar numbers is unlikely. Probably rich harvest of pine nuts will positively affect wild boar population in the near future.

Poaching ungulates from snowmobiles slightly increased this winter because red deer and roe deer came down to Bikin riverbed and valley, although it continued for 1-1.5 months (December and January). Nevertheless in such winters it is reasonable for Tiger Inspection to brisk up the work to prevent or reduce poaching of ungulates from snowmobiles and vehicles.

Ungulate populations should be monitored each year (and during both surveys) with the help of fieldworkers across the whole territory of model unit. As usual each route is covered by the same person each year. These fieldworkers should provide information on ungulates on each route in a simplified way: increase, decrease, the same level in comparison with previous years and even with previous survey and what environmental factors were the reason of this. Fieldworker usually contacts local hunters and should get the necessary information from them to adjust his data obtained from counts of ungulate tracks. Fieldworker should put his conclusions on the last page of Field Diary and coordinator should request such conclusions from each fieldworker. In that case coordinator will have an opportunity to assess the situation in the model unit more carefully and give prognosis for the future.

Thus, in winter 2002-2003 in Bikin model unit the following tigers were registered: 2-3 adult resident males, 3-4 females without cubs, and 1 female with cub, total 7-9 tigers. This year slight increase of tiger numbers was observed in Bikin model unit in comparison with previous year in spite of the fact that tigers are poached here. In comparison with 1995-1996 Tiger Census tiger density in this area is close to normal and is 0.8 individuals per 10,000 ha of primary pine forests.

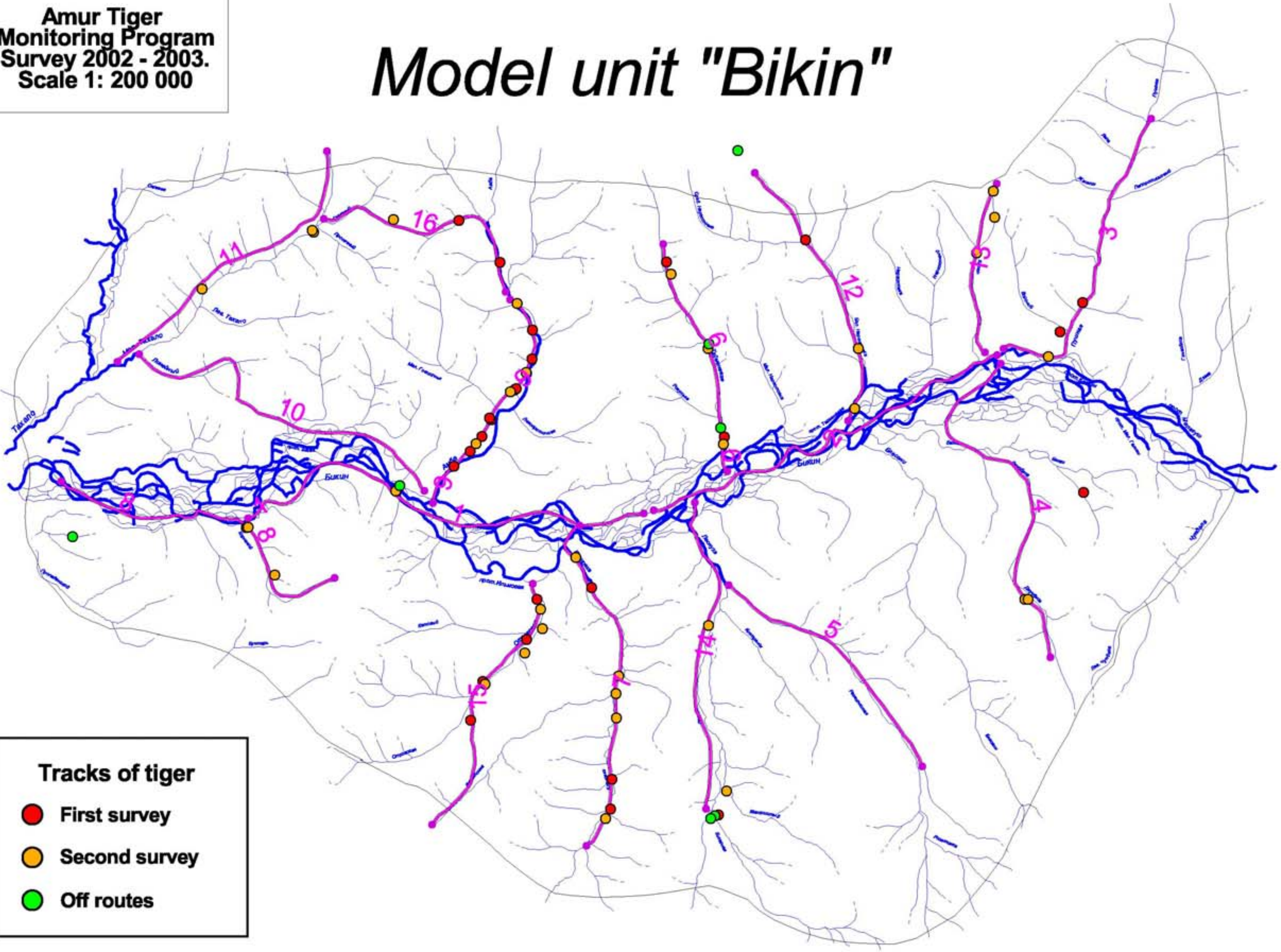
We can state that Bikin river basin remains the important area for Amur tiger in Sikhote-Alin.

Ungulate distribution and numbers in Bikin model unit, winter 2002-2003 (16 survey routes with total length about 200 km

Year		Number of fresh tracks per 10 km of route		
		Red deer	Wild boar	Roe deer
2002	1st survey	6	2	5
	2nd survey	4	1	3
2003	1st survey	12	3	5
	2nd survey	8	3	3

Amur Tiger Monitoring Program Survey 2002 - 2003. Scale 1: 200 000

Model unit "Bikin"



Tracks of tiger

- First survey
- Second survey
- Off routes

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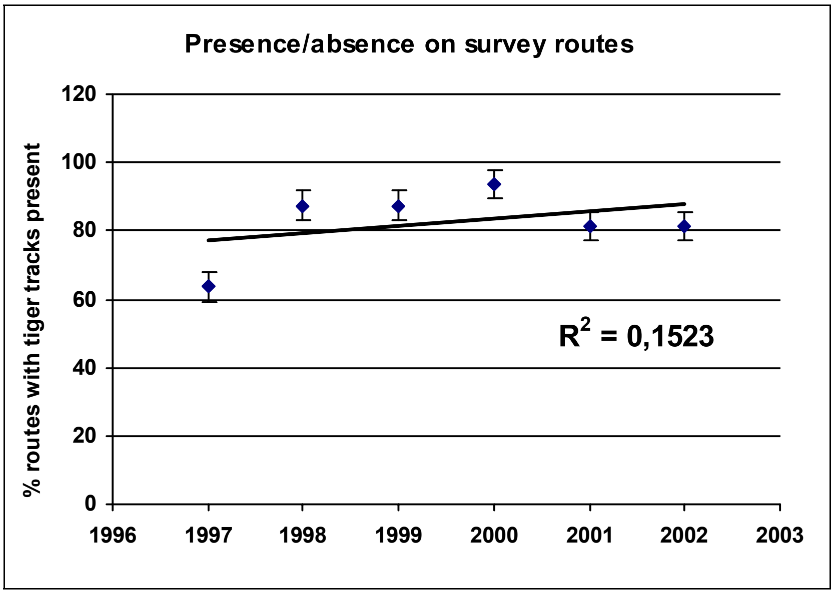
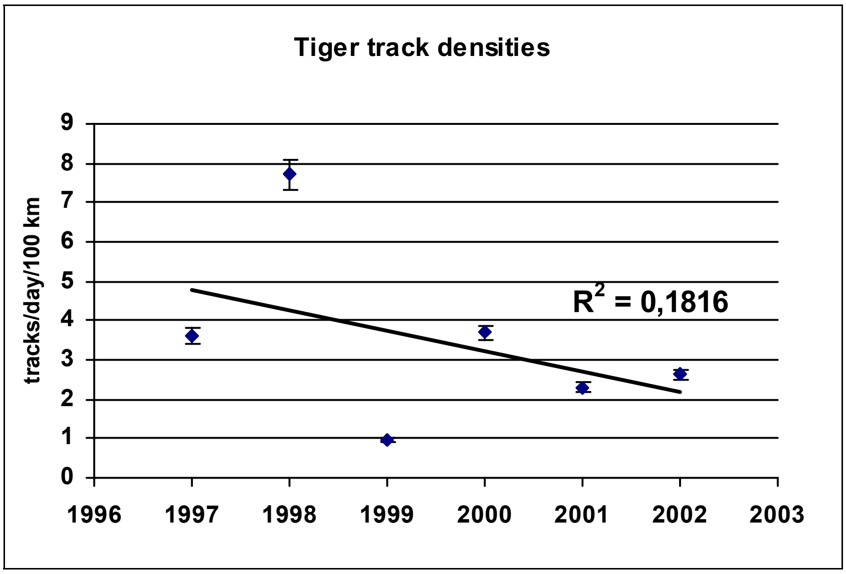
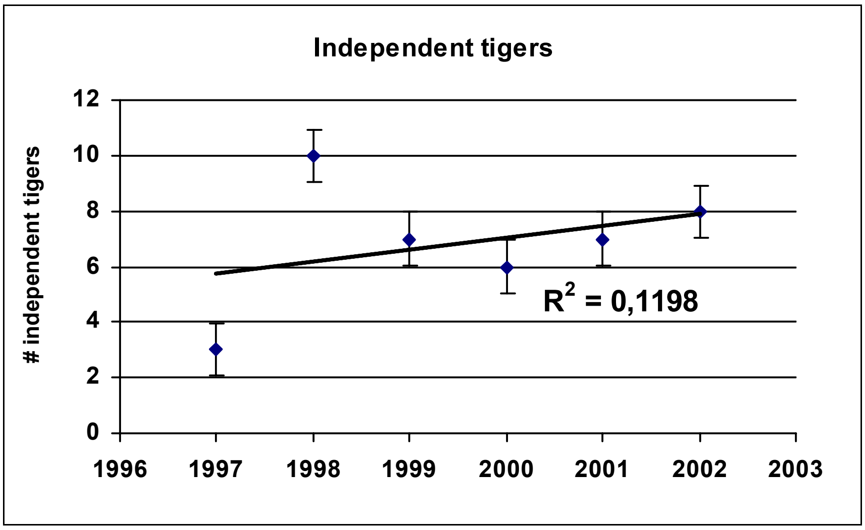

Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1523


Tiger track densities
tracks/day/100 km
9
8
7
6
5
4
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1816

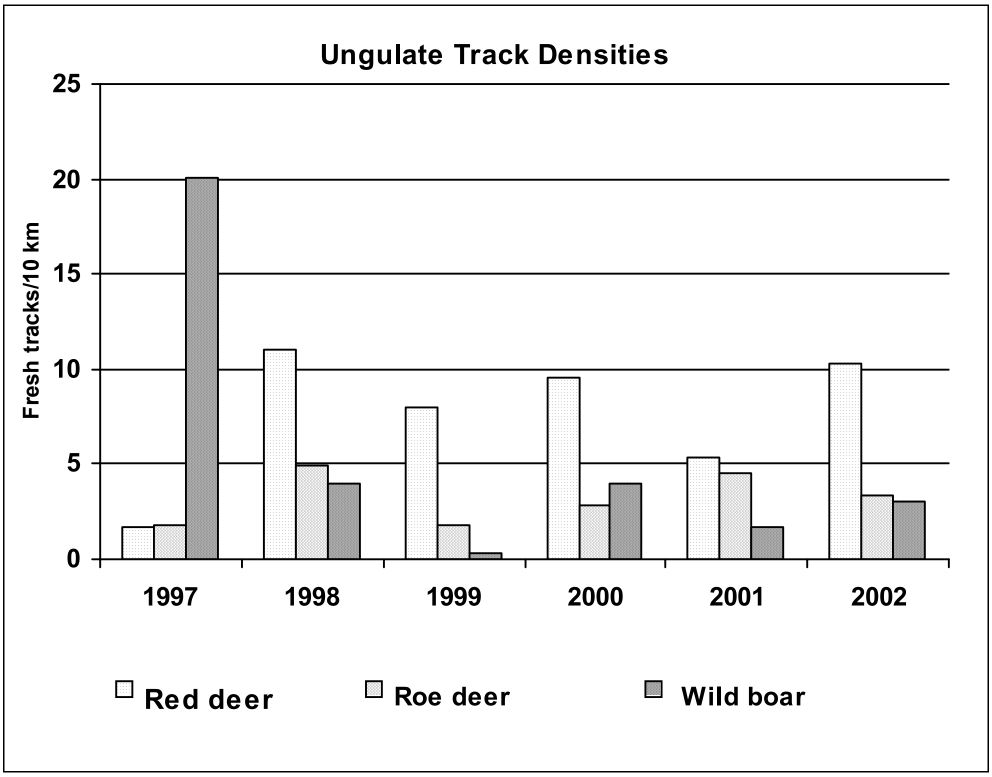

Independent tigers
independent tigers
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,1198

Number of tigers, by age class and sex (for adults only) in “Bikin” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	0	3	0	0	3	0	3	3	6
1998	2	2	0	3	0	2	4	6	6
1999	2	2	1	1	1	1	5	6	7
2000	2	4	0	0	0	0	6	6	6
2001	2	3	0	0	3	0	5	5	8
2002	2	3	0	3	1	0	5	5	6

Mean track density (tracks less than 24 hours) of ungulates in “Bikin” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	16	1.69	1.98	1.83	2.81	0	0	20.09	94.01
1998	16	11.07	12.49	4.98	6.29	0	0	3.96	6.88
1999	16	8.01	9.48	1.74	3.57	0	0	0.3	0.84
2000	16	9.53	11.63	2.88	4.31	0	0	3.97	7.5
2001	16	5.32	6.7	4.49	6.06	0	0	1.69	2.73
2002	16	10.29	16.08	3.41	4.26	0	0	3.08	6.34
Total mean		7.65	9.73	3.22	4.55	0	0	5.52	19.72



SIKHOTE-ALIN STATE BIOSPHERE ZAPOVEDNIK AND TERNEY HUNTING LEASE

(Coastal, or "eastern macroslope" portion of zapovednik)
Northeast Primorsky Krai

Report on results of Amur tiger monitoring program in SABZ and Terney Hunting Lease model units in winter 2002-2003

Coordinator - E. N. Smirnov, Sikhote-Alin State Biosphere Zapovednik

1. Model units: Sikhote-Alin State Biosphere Reserve (SABZ)
   Terney Hunting Lease
2. Coordinator: Smirnov E. N.
3. Time of surveys: January 14-22, 2003
   February 13 - March 4, 2003
4. Numbers of routes: 1-52
5. Total length of routes covered during winter counts:

Survey routes	Total length in January, km	Total length in February, km
SABZ		
On foot	309.5	313
Terney Hunting Lease		
By vehicle	95	95
On foot	105	94
Total		
On foot	414.5	407
By vehicle	95	95

6. *Survey conditions*: First snowfall happened on November 27, 3-5 days later seashore and southern slopes were free of snow. We were waiting for the next snowfall and it fell only on January 4, 2003. Snow depth at some places was deeper than100 cm. The survey began on January 14. Snow was deep therefore some routes were not covered. Such deep snow was not passable for poachers as well and it had positive influence on populations of wild animals. This was corroborated by survey results obtained in February.

The 2nd survey was conducted from February 13 through March 4. There were numerous tracks (mnogosleditsa) because heavy snowfalls did not happen since January 4, except light snow. Snow cover settled down but was present everywhere it its depth was no less than 30 cm.

7-8. *Assessment of efficiency*: In January many tiger tracks could not be measured because of deep snow and in February due to numerous tracks left. How to identify them? To my mind the conditions for survey were unfavorable and tiger numbers were underestimated. It is corroborated by our data on radiocollared tigers (see Attachment). In our opinion, despite specific conditions of this winter the situation with tigers and ungulates in study area remains the same. No dramatic changes happened and status of tiger habitat remains stable for the last 7-8 years. The numbers of wolf, moose and wild boar decreased greatly and sika deer density increased but they do not have a great impact on tiger population.

Attachment to the Report

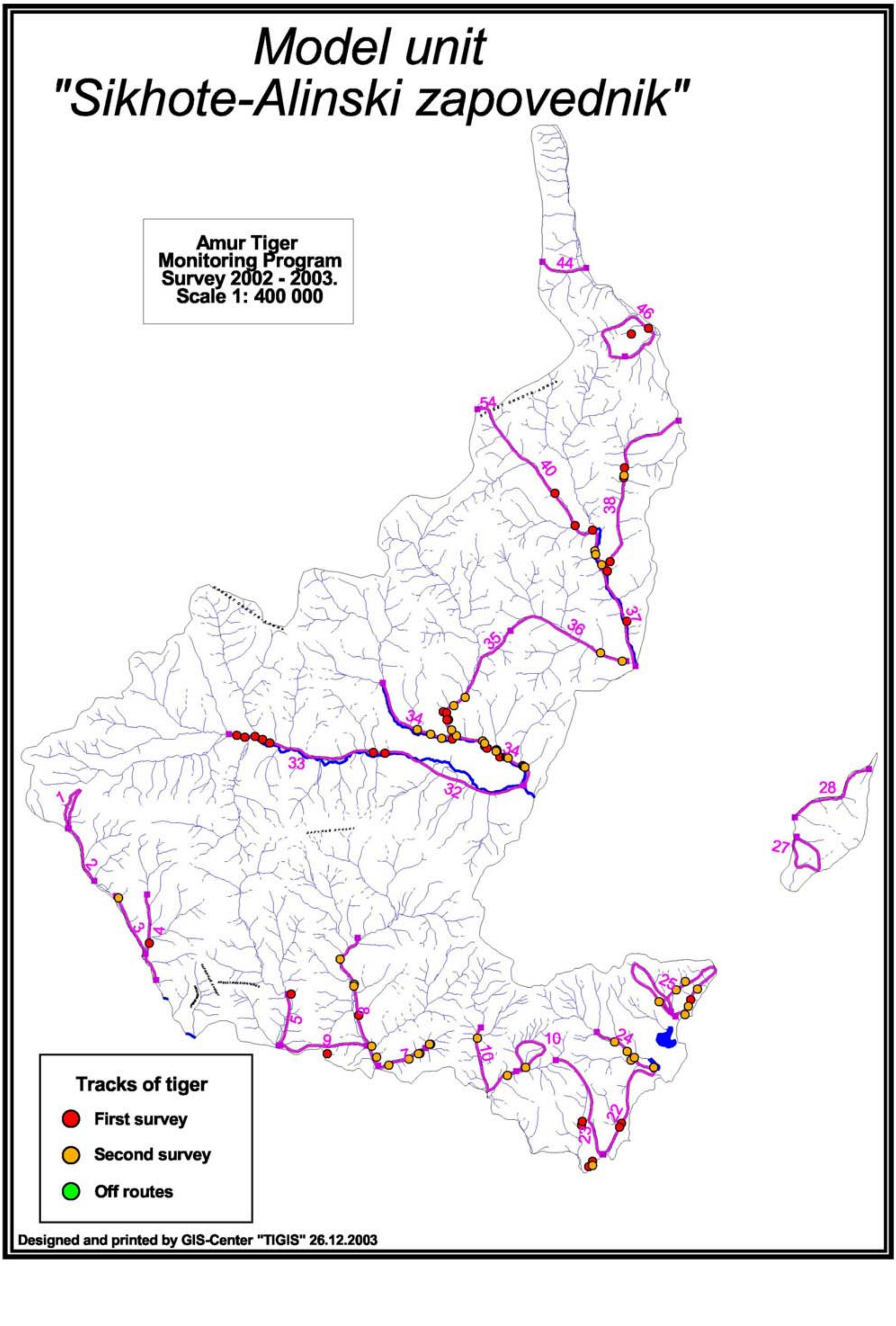
Seven radiocollared tigers, inhabited Blagodatnoe, Inokov creek, Kunaleika and Kuruma river basins in January and February of 2003, were regularly monitored. Their sex, age, date of locations and pad widths as well as tracks registered during surveys are shown in the table below. Many tracks were not measurable. Results of surveys and results of radiotracking are far from each other. We can 100% rely on data of radiotracking and how much can we rely on track counts? In any case tiger tracks ##41-44 and 51-52 do not belong our radiocollared tigers and 10 unmeasured tracks were unidentifiable.

Table 1. Results of surveys in January and February, 2003 and data on radiocollared tigers

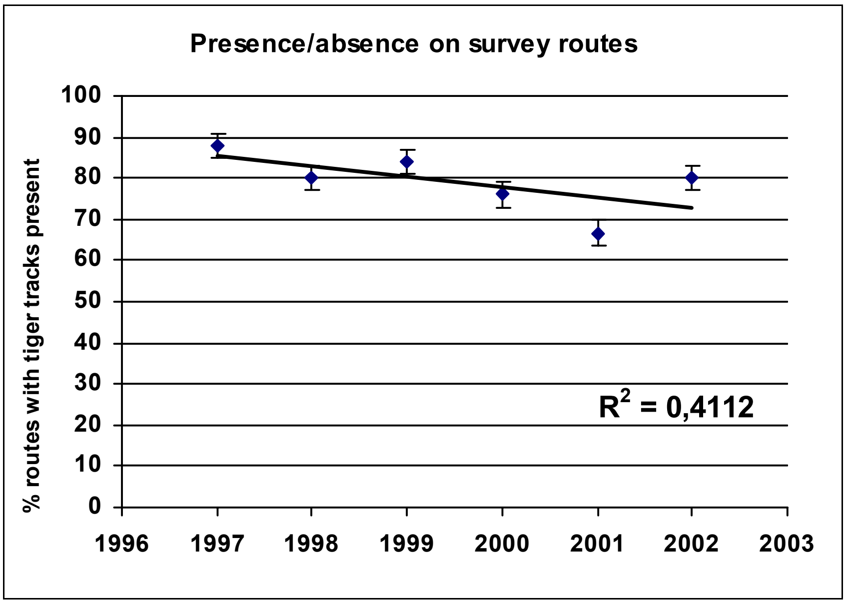
Name	Sex	Age	Pad width, cm	Dates of locations	
				January	February
Vera	female	cub	8.5	14,18,20,22	17,19,24,26
Nelly	female	adult	9.5	14,18,20,22	17,19,24,26
Galya	female	cub	8.5	14,18,20,22	17,19,24,26
Vasya	male	cub	10.5	14,18,20,22	17,19,24,26
Volodya	male	adult	11.5	14,18,20,22	17,19,24,26
Roma	male	cub	10	14,18,20,22	17,19,24,26
Lidia	female	adult	9	14,18,20,22	17,19,24,26

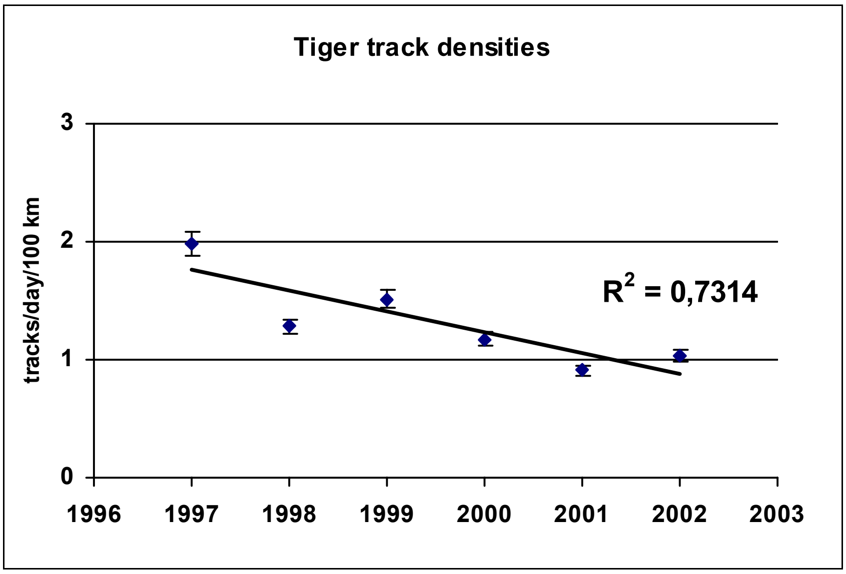
During survey in January 4 tigers were registered: with pad width 9 cm, 10 cm and 10.5 cm. Three tracks were not measured: they were old and the fourth was not measured because of deep snow.

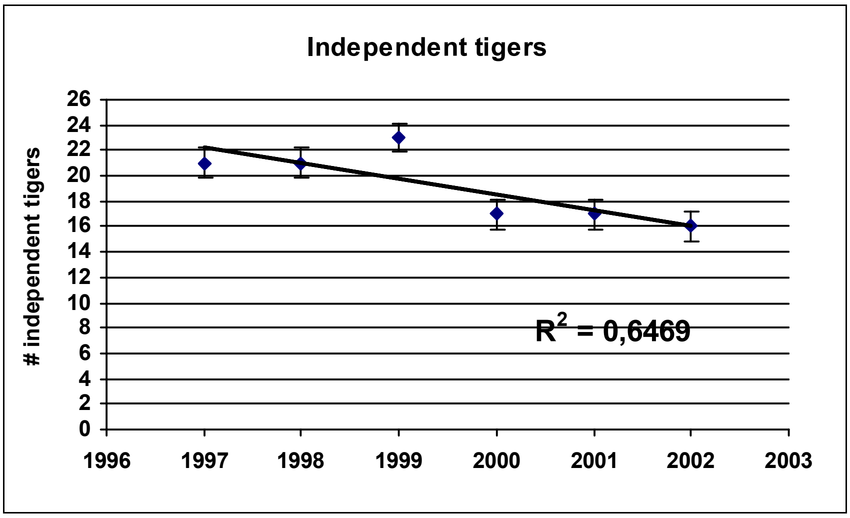
During survey in February 7 tigers were registered: with pad width 10 cm and 7 cm (together) – probably not radiocollared tigers, with pad width 9 cm and 10 cm (together), with pad width 9 cm, 10 cm, and 10.5 cm (how many of them?). Seven tracks could not be measured.



Model unit
"Sikhote-Alinski zapovednik"
Amur Tiger
Monitoring Program
Survey 2002 - 2003.
Scale 1: 400 000
Tracks of tiger
First survey
Second survey
Off routes
Designed and printed by GIS-Center "TIGIS" 26.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
100
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,4112


Tiger track densities
tracks/day/100 km
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,7314

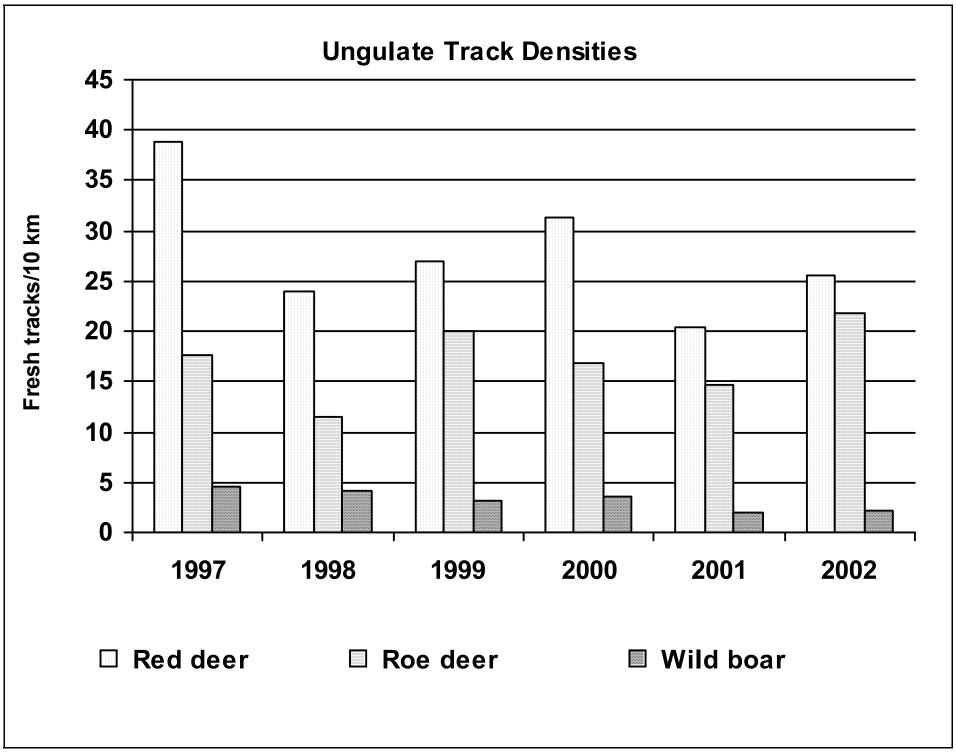

Independent tigers
independent tigers
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,6469

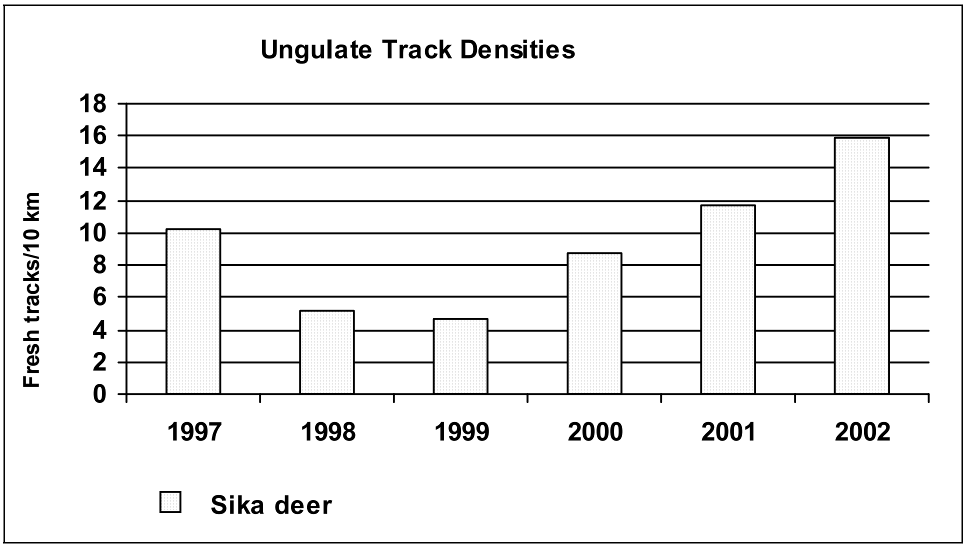
Number of tigers, by age class and sex (for adults only) in “Sikhote-Alin Zapovednik” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	8	9	4	0	9	4	21	25	34
1998	7	5	7	1	4	8	19	27	31
1999	7	7	5	4	1	5	19	24	25
2000	3	7	1	2	4	5	11	16	20
2001	6	8	1	0	0	3	15	18	18
2002	2	3	9	1	2	10	14	24	26

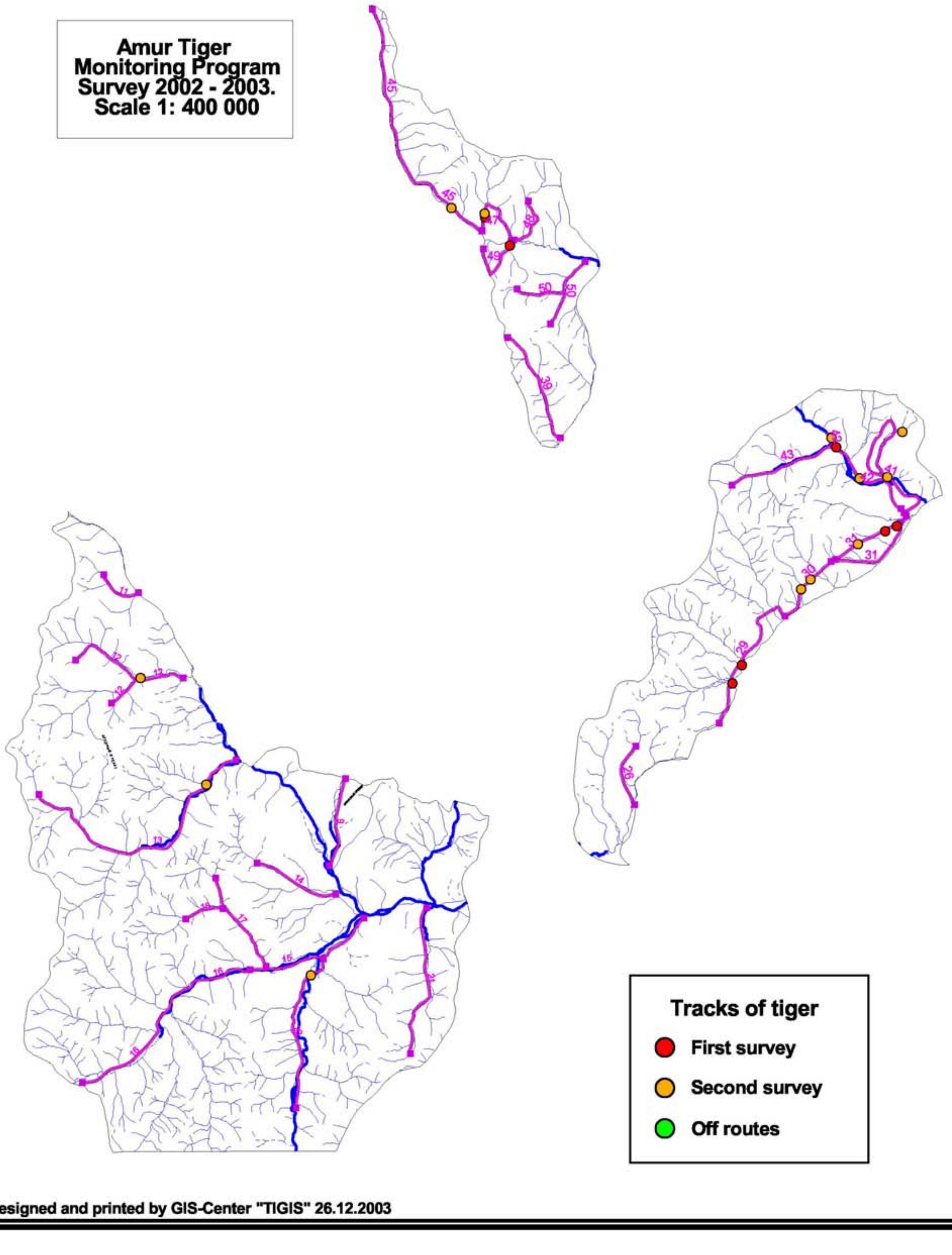
Mean track density (tracks less than 24 hours) of ungulates in “Sikhote-Alin Zapovednik” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	46	38.86	67.48	17.6	43.18	10.24	40.35	4.6	6.48
1998	46	23.98	24.75	11.5	18.84	5.18	14.63	4.21	6.63
1999	46	27.02	27.9	20.05	23.8	4.68	14.78	3.25	5.49
2000	46	31.28	23.51	16.77	22	8.71	24.38	3.57	5.74
2001	46	20.42	20.36	14.61	15.91	11.75	34.18	2.05	6.5
2002	46	25.65	22.45	21.75	24.04	15.85	39.58	2.16	3.32
Total mean		27.87	31.08	17.05	24.63	9.4	27.98	3.3	5.7




Ungulate Track Densities
18
16
14
12
10
8
6
4
2
0
Fresh tracks/10 km
1997
1998
1999
2000
2001
2002
Sika deer

Model unit "Terneyskoe okhotkhozyaystvo"



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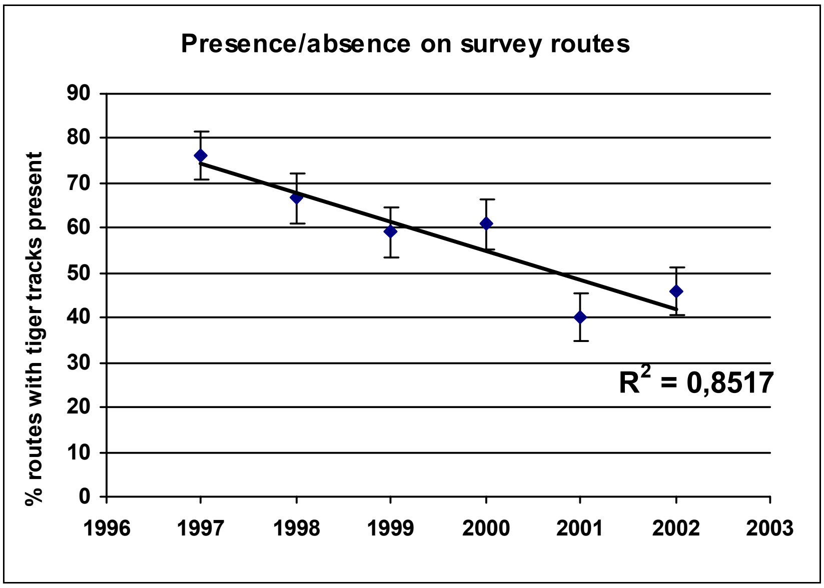
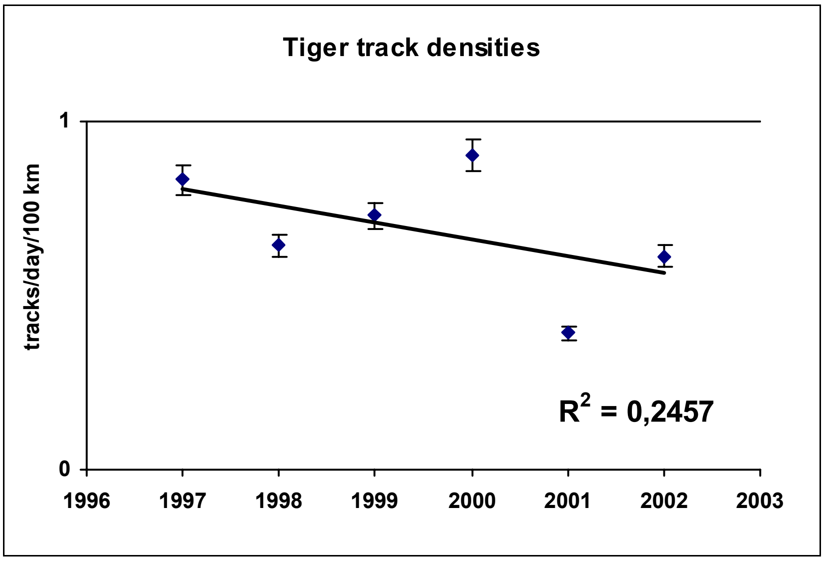
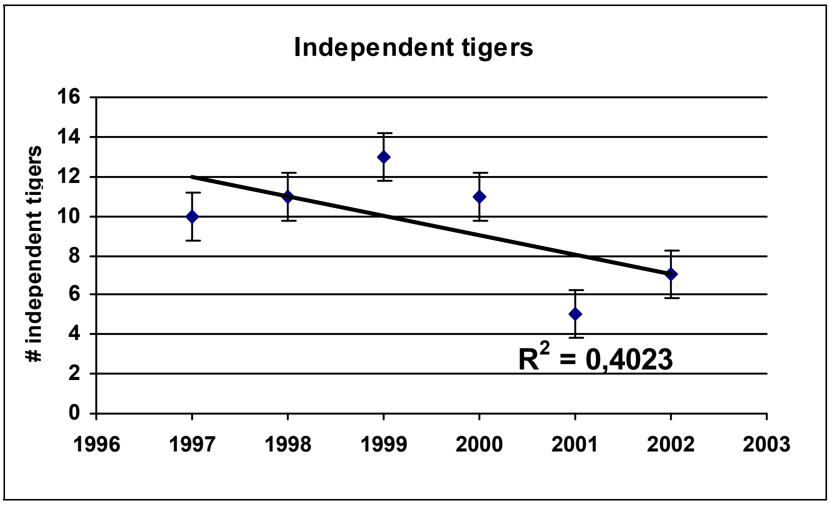


Presence/absence on survey routes
% routes with tiger tracks present
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,8517



Tiger track densities
tracks/day/100 km
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,2457



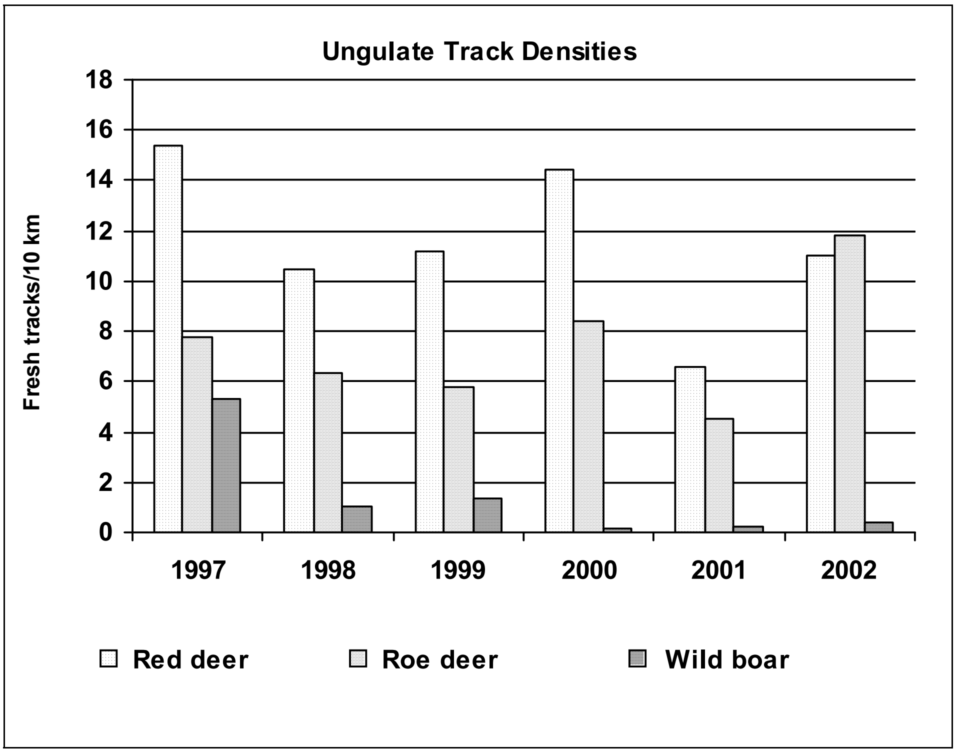
Independent tigers
independent tigers
16
14
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,4023

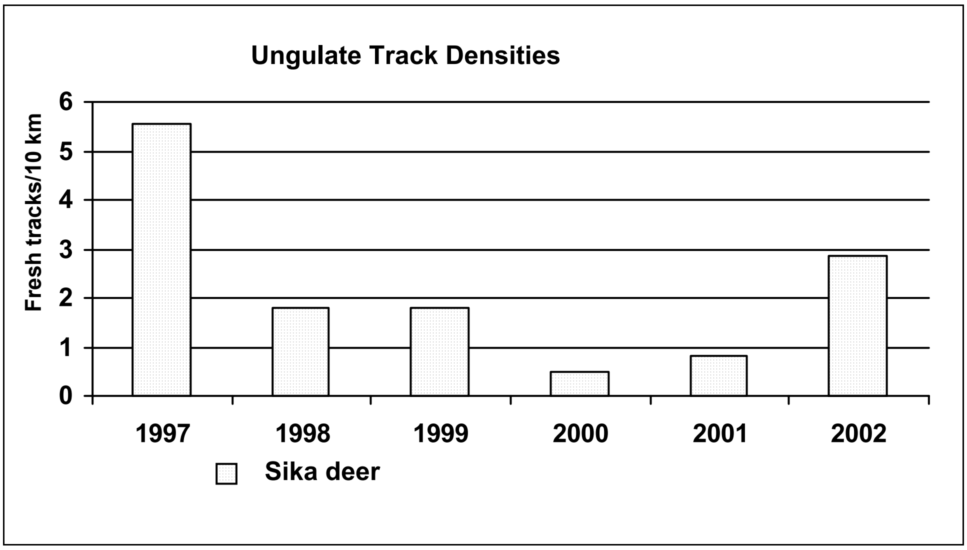
Number of tigers, by age class and sex (for adults only) in “Terney Hunting Lease” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	2	3	4	1	5	4	9	13	18
1998	2	4	4	1	2	4	10	14	16
1999	5	5	3	0	1	3	13	16	17
2000	3	3	3	0	1	5	9	14	15
2001	1	3	1	0	1	1	5	6	7
2002	1	3	3	0	0	3	7	10	10

Mean track density (tracks less than 24 hours) of ungulates in “Terney Hunting Lease” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	50	15.36	17.81	7.81	11.16	5.54	25.59	5.31	23.19
1998	50	10.5	13.37	6.33	13.29	1.8	7.67	1.06	2.73
1999	50	11.22	12.74	5.76	10.35	1.8	7.01	1.39	2.85
2000	50	14.43	13.13	8.42	14	0.48	1.55	0.16	0.68
2001	50	6.59	7.29	4.53	7.47	0.82	3.82	0.22	1.09
2002	50	11	19.37	11.82	17.02	2.86	8.61	0.42	1.31
Total mean		11.52	13.95	7.44	12.21	2.22	9.04	1.42	5.31





Ungulate Track Densities
Fresh tracks/10 km
6
5
4
3
2
1
0
1997
1998
1999
2000
2001
2002
Sika deer

MATAI
KHOR
TIGRINI DOM
BOLSHE-KHEKHTSIRSKI ZAPOVEDNIK
BOTCHINSKI ZAPOVEDNIK
Khabarovskiy Krai

Report on results of Amur tiger monitoring program in Khabarovskiy Krai in winter 2002-2003

Coordinator - Yu. M. Dunishenko, All Russia Research Institute of Wildlife Management, Hunting, and Farming

Preamble

This year Amur Tiger Monitoring program was financed by WCS and Global Environmental Foundation by providing funds for the project “Development of protected area network for Sikhote-Alin mountains conservation in Khabarovsky Krai”. DVO VNIIOZ provided workrooms and office equipment. We thank all these organizations.

Data was collected and processed by scientists from DVO VNIIOZ - A. M. Golub, A. A. Darenskiy, V. V. Dolinin, D. A. Zvyagintsev, K.N. Tkachenko (research scientist from Bolshe-Khekhtsirsky Reserve) and S. V. Kostomarov (the Director of Botchinsky Reserve).

We thank many local specialists and hunters for their effective great work in the field, which they did for a small consideration. Without their help it wouldn’t be possible to complete all these tasks.

Taking into account great work content we decided to include only results of our work in this report. Extensive original data in tables, data sheets, diaries and maps is kept in VNIIOZ and is accessible to the public.

This report was prepared and written by senior staff scientist of VNIIOZ Yu. M. Dunishenko.

1. Introduction

Environmental conditions in winter 2002-2003 were favorable for tigers and wild ungulates. The harvest of acorns and pine nuts was above the average in all areas and snow depth was normal. Heavy snowfalls happened in early December followed by 8-12 hour rainfalls throughout tiger range. The following hard frost made environmental conditions more difficult and caused top-down animal migrations but did not cause animal deaths. Ice crust did not impede animals’ travels. At the same time its rustle hampered successful hunting by predators and hunters alike, because it was impossible to approach ungulates unnoticed. As a result of this, most of hunters were not able to use their licenses and tigers had to switch to feeding on wild boars.

Nevertheless, usual distribution of animals had changed. In December in most areas red deer and roe deer did not occur higher than 300-350 m above sea level, wild boars preferred staying in pine forests, where snow depth was less and pinecones were falling down during the whole winter. Moreover, rain strength was not equal in all places and animals concentrated in areas, where icy crust was not hard. Unevenness of pine forests distribution caused corresponding distribution of wild boars and tigers. In this connection on many routes, where tiger tracks were registered every year, they were not found during the 1st survey. By the time of the 2nd survey the situation improved. Icy crust disappeared, no heavy snowfalls happened and animals partly returned to the slopes. In the second half of winter animals very actively visited areas near the roads and it resulted in high level of poaching using vehicles.

Weather conditions were favorable for successful survey conducting. All survey routes were covered in time without deviation from methodology. Total length of all routes covered during 6 years of monitoring program is 11,810 km and dozens of thousands of kilometers were covered to bring people to survey routes. The work was done by local specialists, owners of hunting leases, staff of reserves and zakazniks. All efforts were coordinated by scientists from DVO VNIIOZ . A lot of help and support was provided by the Administration of Khabarovsky Krai.

Using 3 different grants’ money and partially VNIIOZ funds we purchased within the last three year period of time two GPS receivers, two snowmobiles and 4WD vehicle (UAZ). This equipment proved to be extremely helpful t in conducting fieldwork. The problem, which is still not resolved, is lack of safety equipment. We still need wildlife protection gear, three more GPS receivers, photo cameras, at least 10 walkie-talkie sets, etc. Additionally, we need funds to build cabins for overnighting because worsening quality of forest roads make return trips a problem.

This report contains information accumulated during 6 years of monitoring program (Table 1.1 and 1.2).

Table 1.1. Survey schedule and work content in model units, 2002-2003 winter season

Model units	Time of survey		Number of field-workers	Total length of all routes traveled during 2 surveys, km	Years and kilometers traveled per 1,000 ha					
	1st survey	2nd survey			02/03	01/02	00/01	99/00	98/99	97/98
Matai	02.12.08-02.12.25	03.02.11-03.02.28	4	754	2.95	2.95	2.95	2.95	2.81	2.9
Khor	02.12.17-02.12.26	03.02.08-03.02.25	5	478	3.63	3.63	3.63	3.39	2.96	2.42
Khekhtsir	02.11.29-02.12.01	03.02.11-03.02.21	9	140	3.1	3.1	3.1	3.1	3.1	3.0
Tigriny Dom	02.12.10-02.12.25	03.02.18-03.02.24	3	384	1.82	1.82	1.82	1.82	1.83	1.38
Botchinsky	03.01.03-03.01.15	0302.17-03.02.26	7	320	1.04	1.04	1.04	1.04	0.95	1.13
Total			**28**	**2076**	**2.19**	**2.19**	**2.19**	**2.15**	**2.02**	**1.93**

Table 1.2. Work conducted during tiger monitoring program, winter 2002-2003

Model units	Area, thousand ha	Number of routes	Total length of routes, km		1st survey			2nd survey		
			1st survey	2nd survey	vehicle	snow-mobile	on foot	vehicle	snow-mobile	on foot
Matai	255.4	24	377	377	232	104	41	184	150	43
Khor	131.5	21	239	239	61	149	29	75	139	25
Khekhtsir	45.1	7	70	70	0	0	70	0	0	70
Tigriny Dom	210.7	14	192	192	116	0	76	116	0	76
Botchinsky	307.0	14	160	160	20	59	81	20	84	56
Total	**949.7**	**80**	**1038**	**1038**	**429**	**312**	**297**	**395**	**373**	**270**

Note: route length was measured with curvimeter and may differ from computer variant

2. Monitoring of tiger prey species

During last three years environmental conditions were favorable for ungulate reproduction and survival of young animals. At the same time weather conditions were not favorable for hunting and poaching. In summer, rains or drought prevented successful hunting, in early winter icy crust impeded stalking of prey, followed by hard frosts, and spring periods, when ungulate death-rate is especially high due to icy crust were either very short or none at all. Moreover, the decrease of large predators numbers is observed. All the above mentioned factors caused reduction of ungulate population decrease rates and changes in population trends. Still, the situation with different species in different habitats is not the same.

Red deer. According to the results of this year survey, population growth, which began in 2001, continues and became more evident (Table 2.1, 2.2, Figure 2.1).

The increase in number of red deer tracks per 10 km of survey route in the second half of winter does not necessarily mean a well-being of the population. It is contrary to our logic and most probably is evidence of animal migrations. Nevertheless, the number of survey routes with red deer tracks is increasing (Table 2.3) and it may be the indirect sign of populating the range. In general, red deer density is low and the situation does not exclude the necessity of population recovery measures.

Table 2.1. Wild ungulates encountered (individuals per 10 km of route) in total of two counts during different years

Model units	Red deer					Wild boar					Roe deer				
	98/99	99/00	00/01	01/02	02/03	98/99	99/00	00/01	01/02	02/03	98/99	99/00	00/01	01/02	02/03
Matai	4.68	3.63	1.64	2.53	3.83	1.07	2.07	1.31	0.45	5.21	2.51	2.08	1.24	1.18	2.48
Khor	5.82	3.18	2.99	2.22	4.41	0.77	0.22	1.56	1.03	1.59	6.56	2.20	1.78	3.58	1.88
Tigriny Dom	4.69	1.20	0.94	1.51	1.64	0.83	0.96	0.34	0.10	0.13	0.91	0.31	0.23	0.42	0.08
Khekhtsir	16.64	14.57	10.57	13.0	15.64	3.21	0.78	1.28	1.21	8.36	1.36	0.14	1.0	2.14	0.64
Botchinsky	7.94	4.25	2.21	4.19	4.63	0	0	0	0	0	3.49	2.75	3.34	3.59	5.25
Total	**6.28**	**3.52**	**3.67**	**3.23**	**4.48**	**0.95**	**1.05**	**0.9**	**0.50**	**2.85**	**3.07**	**1.74**	**1.51**	**2.03**	**2.20**

Figure 2.1

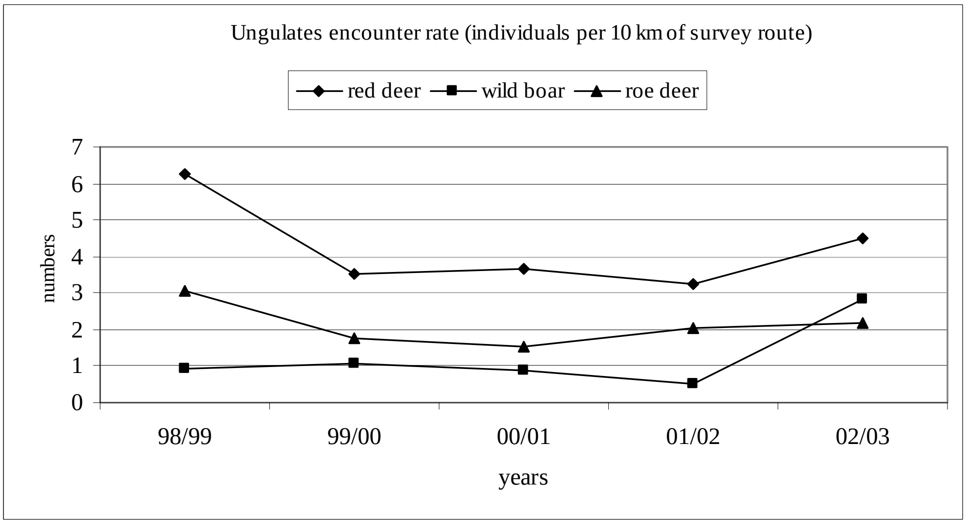


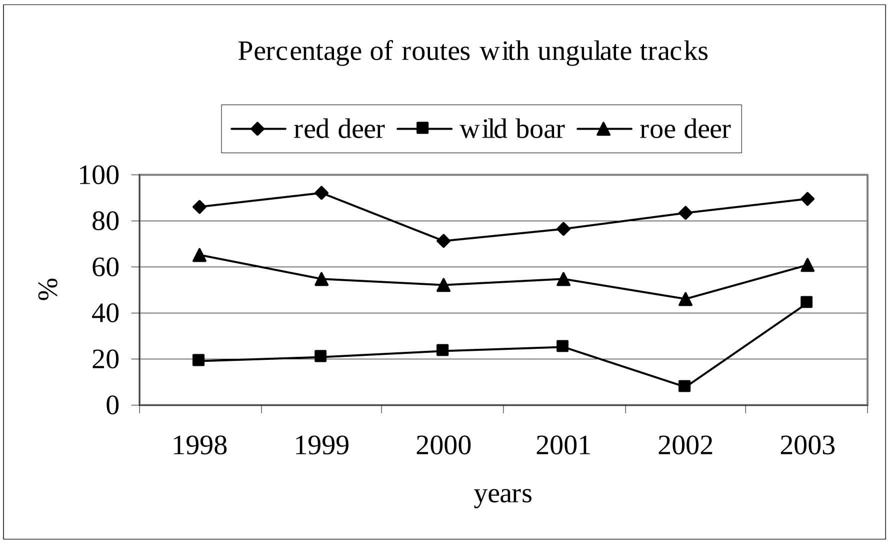
Table 2.2. Wild ungulates encountered on routes during winter season 2002-2003

Model units	# individuals per 10 km of survey route								Difference (+/-%) between surveys
	1st survey				2nd survey				
	Red deer	Wild boar	Roe deer	Total	Red deer	Wild boar	Roe deer	Total	
Matai	3.26	6.05	2.44	14.75	4.40	4.38	2.52	11.13	-24.6
Khor	4.39	1.72	1.26	7.37	4.43	1.46	2.51	8.4	+14.0
Tigriny Dom	1.14	0.2	0.05	1.39	2.13	0.05	0.1	2.28	+64.0
Khekhtsir	15.86	5.85	0.71	22.42	15.14	10.86	0.57	26.57	+18.5
Botchinsky	6.81	0	6.31	13.12	2.44	0	4.19	6.63	-49.8
Total	**4.53**	**3.58**	**2.20**	**10.31**	**4.43**	**3.15**	**2.19**	**9.77**	**-5.3**

Table 2.3. Percentage of survey routes with ungulates tracks in February of each year

Model units	% of routes with ungulate tracks																	
	Red deer						Wild boar						Roe deer					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Matai	90.0	91.7	75.0	83.3	79.2	100	60.0	37.5	66.7	54.2	8.4	87.5	90.0	83.3	79.2	83.3	62.5	87.5
Khor	82.3	82.3	47.6	66.7	71.4	90.5	17.6	17.6	9.5	14.3	19.0	38.1	52.9	52.9	38.1	42.8	38.1	66.7
Tigriny Dom	90.0	92.8	64.3	57.1	85.7	64.3	20.0	21.4	0	21.4	0	7.1	40.0	21.4	7.1	21.4	14.3	14.3
Khekhtsir	85.7	100	85.7	100	100	100	0	14.3	14.3	14.3	0	71.4	28.6	28.6	0	42.8	28.6	28.6
Botchinsky	85.7	100	100	85.7	100	7.14	0	0	0	0	0	0	100	57.1	42.8	71.4	71.4	71.4
Total	**86.2**	**92.1**	**71.2**	**76.2**	**83.8**	**90.0**	**18.9**	**21.0**	**23.7**	**25.0**	**7.5**	**44.3**	**65.5**	**55.2**	**52.5**	**55.0**	**46.3**	**61.2**

Figure 2.2



Wild boar. High reproductive capacity of wild boar population causes abrupt changes in wild boar numbers. Field data obtained in recent years showed that wild boar numbers declined since 2001, but data obtained in winter 2002-2003 proved the reverse. Wild boar numbers increased noticeably. This winter large herds consisted of 20-30 individuals were observed more often, litter size and survival increased. It may be assumed that generally wild boar population is still growing and decrease of numbers was temporary. Favorable conditions of last wintering were one of the reasons – when wild boars feed on pine nuts they move a lot and hunters do not have enough time to come up with wild boar herd in daylight. This is a reason of great increase of track numbers on survey routes. One of the most important reasons for the positive population trend is a rapid growth of wild boar population outside of tiger range, in wetlands on the right bank of Amur river (lower reaches of Sita, Obor, Kuznechikha, Mukhen and other rivers), where there are many oak groves. If there is no harvest of acorns wild boars disperse in adjacent areas and it helps to mitigate losses in wild boar population in tiger range. Obviously this is the reason of continuous increase of tiger numbers in Tigriny Dom model unit. Outside of tiger range, the wild boar population growth rates are controlled by growing numbers of wolves.

In spite of encouraging positive changes, the recovery of wild boar and red deer populations is still needed. Therefore, it is necessary to establish sites with stable forage resources in key habitats of these species. Education programs for hunting leases are also very important, because the lack of trained staff in most of them results in game species' reproduction rates decrease. Hunters prefer killing adult females and cause more damage to population than predators, which prefer killing young individuals.

Roe deer. Situation with roe deer population is not simple. Information obtained during surveys show patchy distribution of roe deer and data on population trends are conflicting. It was confirmed during surveys in model units. Increase of roe deer numbers was observed only in Mataisky and Botchinsky model units. Still, judging by number of roe deer tracks increase on survey routes (Table 2.3) the population growth trend starting from 2000/01 season is quite obvious. It is necessary to mention that roe deer, when wild boar is absent, can play critical role in tiger cubs survival. Additionally we receive the information about increase of lynx numbers. Probably this is the reason of its relatively low density. Roe deer is hard prey for hunters in Ussuri taiga therefore commercial hunting does not influence the population significantly. Roe deer are mostly hunted when they migrate and come out into open areas in Ussuri river valley, where they concentrate along KSP. Such events were not reported for the last 15 years.

Sika deer. Information about casual shots of sika deer in Khabarovsky Krai is known since 1979. Mostly they happened in Khor river basin (middle reaches, Matai river, mouths of Kafen and Katen rivers, and portion of Khor river from Kutuzovka to Khody non-existing at present time). Northernmost area, where sika deer was shot, is mouth of Nizhnie Buge creek (inflowing Khor from the right below Sukpai mouth).

In late 1970-s hunting lease manager Batalov A.S. found group consisted of 6 sika deer on southern slopes on the right bank of Khor river, 2 km above Kutuzovka village. Later in the same area the group of five, then four and then three animals was observed. During last 5 years sika deer were not found there and we think those animals were migrants from Primorsky Krai and they died. Nevertheless, information about single sika deer and even groups of 3-8 animals was received, but all these sika deer were observed outside of the known site in Khor model unit.

We do not have irrefutable proof of sika deer presence and so did not include this species in tiger prey resources. Modern hunters of Khabarovsky Krai are not familiar with sika deer. There are also very few reported cases of visual encounters by specialists all of them lacking infallible proving information Special survey of potential area was not conducted due to lack of funds. Local hunting leases during their surveys identified some of tracks as belonging to young red deer but thorough study of the area was impossible due to extreme steepness (40-70^o) of southern slopes.

For the first time we had a chance to examine dead adult female sika deer, which fell down from the cliff, on February 25, 2003. We interviewed rangers and hunters here and found out that sika deer still inhabit this area and during all these years sika deer range was extending and now sika deer are common on the left bank of Khor river as well. In winter sika deer inhabit steep southern slopes, where snow cover is not deep. Animals prefer oak forests with other deciduous tree species. Here they find abundant forage as well as, landscape features provide protection against successful tiger predation.

Appearance of sika deer in Khabarovsky Krai is probably explained by quick extension of its range in Primorye. Probably they come to Khabarovsky Krai from Sikhote-Alin Reserve or Pozharsky Raion, because migration of sika deer from Chinese territory is virtually impossible.

There are high potentials for sika deer habitat increase in Khabarovskiy Krai that could be quite intensively realized under the right policies enactment.. Among predators only lynx can control sika deer distribution because of high lynx density in sika deer habitat. Wolves are virtually absent here because they are displaced by tigers. At the same time sika deer is not important for tiger as prey species, because it is easier for tiger to prey on wild boar or red deer. Moreover sika deer prefer staying on steep slopes and it makes them inaccessible for tigers. But it is temporary phenomenon. When sika deer is common in southern part of Khabarovsky Krai it will become one of the components of tiger diet. In this connection, monitoring of sika deer population is needed to determine reintroduction strategy and necessary measures in order to support recovery of ungulate populations in tiger range.

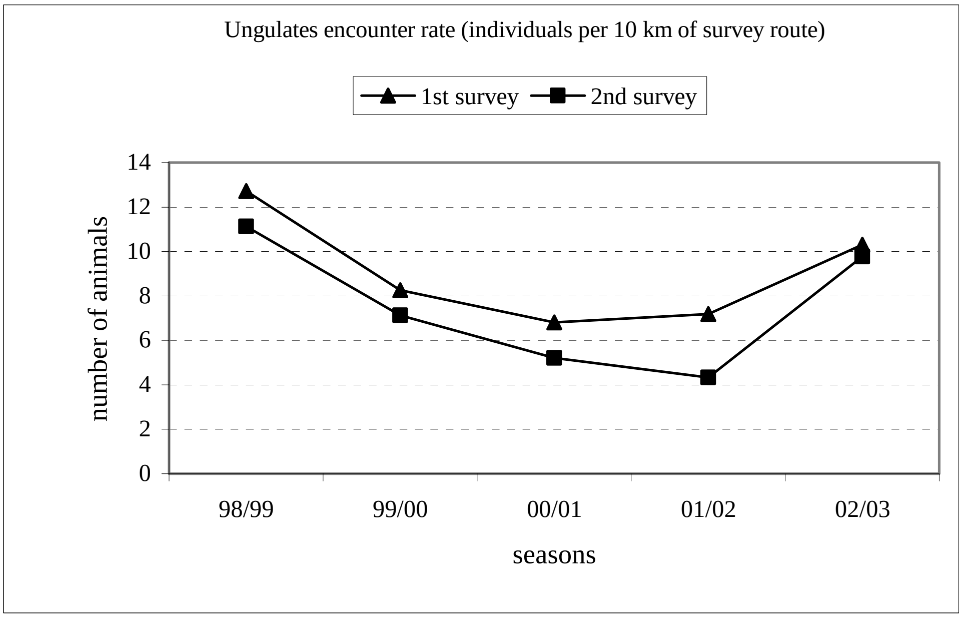
Based on the analysis of the total density of fresh ungulate tracks (red deer, wild boar, roe deer) on survey routes one can conclude that the total forage availability is increasing, if only this is not a temporary phenomenon (Table 2.4, Figure 2.3).

Some distortion took place in 2002-2003 season due to vertical migrations of ungulates. In most of model units ungulate track encounter rate in February was higher than in December, but generally the difference between number of tracks during the 1st and the 2nd surveys decreased significantly.

Table 2.4. Total number of ungulates on survey routes (individuals per 10 km) based on fresh track density

Model units	1st survey					2nd survey				
	1998	1999	2000	2001	2002	1999	2000	2001	2002	2003
Matai	6.92	8.03	3.05	4.1	14.75	9.35	7.53	5.35	4.22	11.13
Khor	16.34	7.34	7.9	10.54	7.37	9.5	4.1	4.77	12.1	8.4
Tigriny Dom	5.33	3.23	1.88	5.16	1.39	7.53	1.71	1.15	1.51	2.28
Khekhtsir	23.86	16.72	15.43	18.5	22.42	18.0	14.24	10.28	20.6	26.57
Botchinsky	11.1	5.94	6.62	8.87	13.12	11.3	8.06	4.49	6.69	6.63
Total	**12.71**	**8.25**	**6.81**	**7.19**	**10.31**	**11.13**	**7.13**	**5.21**	**4.33**	**9.77**

Figure 2.3



3. Changes of habitat

Information about changes of habitat given in Table 3.1 is not quite objective. Length of forest roads is inconstant because they are mostly winter roads, which are deteriorating quickly. Nobody knows their length exactly and it is impossible to investigate all of them during surveys. The same situation is with logging area, different methods of forest exploitation are used and official information does not reflect actual situation. The information about the number of logging sites is more reliable, but also does not reflect existing situation completely, because winter logging sites and summer logging sites are usually different. In winter loggers often moved from one site to another, therefore these factors could be underestimated. Nevertheless, this data show that logging is still increasing in Matai river basin, where areas became accessible due to the construction of the highway from Khabarovsk to Nakhodka. Besides, this forest mainly consists of ashes, oaks, pines and linden tree species that are valued for unlimited market and high markets price.

The problem with compensation by loggers for resource restoration is still not resolved DVO VNIIOZ annually makes accounts for dozens of logging sites but there are no examples of purposeful use of such funds.

Table 3.1. Changes of tiger habitat

Model units	Anthropogenic factors											
	New roads built, km				# of logging sites				Logging area, ha			
	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003
Matai	24	52	60	291	27	65	69	119	2002	2500	2600	996
Khor	16	-	5	3	10	7	31	17	850	260	400	700
Tigriny Dom	0	0	30	15	7	13	12	15	520	50	0	240
Khekhtsir	0	0	0	0	0	0	0	0	0	0	0	0
Botchinsky	0	0	0	0	0	0	0	0	0	0	0	0
Total	**40**	**52**	**95**	**309**	**44**	**85**	**112**	**151**	**3372**	**2810**	**3000**	**1936**

4. Results of tiger numbers monitoring

Based on the results of survey 2002-2003 tiger numbers in model units decreased by 12.5% (Table 4.1). As in previous years changes are illogical. Deep snow cover in mountainous part of tiger range caused top-down migrations of ungulates and should have caused the increase of tiger numbers in model units as it was last winter. The decrease was observed in Khorsky and Botchinsky model units. It is necessary to mention that presence of 4 tigers registered in Botchinsky model unit (if to base on track analysis) is questionable. Most likely only three tigers remained there. In Matai model unit significant decrease of tiger numbers was also observed. The fifth tiger rarely visited this territory moving from Primorsky Krai. In Tigriny Dom model unit additional female was found. Probably she came from adjacent area to mate with resident male. This female was registered near the border of the model unit. Therefore actual number of tigers in model units can differ greatly from data given in Table 4.1.

It is necessary to mention that model units, except Botchinsky, are under the regular control of local specialists, hunters and scientists from DVO VNIIOZ. Actually all tigers here are monitored almost all the year round and survey results only confirm their number. Outside of model units decrease of tiger numbers is observed in marginal areas of tiger range. This winter tigers were less common in Komsomolskiy Raion. Only one male was registered here and according to unofficial information it was killed in the end of February. Most of hunters and local specialists, which were interviewed, confirmed the decrease of tiger numbers. Only 30% of interviewed hunters and specialists consider tiger population to be stable.

Generally, tiger density in model units is nearly stable. Nevertheless, the decrease by 12.7% in comparison with last winter may be alarming if all information mentioned above and current negative changes are taken into account.

Analyzing the number of tiger tracks no older than 7 days in relation to the number of registered tigers no direct correlation was revealed (Table 4.2). It may depend on survey conditions, ungulate activity, densities, and other reasons including personality and qualification of fieldworker.

No correlation between tiger numbers and the number of survey routes with tiger tracks was revealed (Table 4.3, Figure 4.1).

Thus during 6 years of monitoring program 506 tiger tracks no older than 7 days were registered. In average 4.22 tiger tracks were registered per 1 identified individual and average density is 0.4 tiger track per 10 km of survey routes. In other words, in tiger habitat one relatively fresh tiger track could be found per 25 km of survey routes during this season.

In all model units except Botchinsky and Tigriny Dom the number of survey routes with tiger tracks is decreasing during last 4 years. Probably it is connected with snow distribution. The deeper snow cover in mountains the less number of survey routes with tiger tracks are here. But we also cannot rule out the possibility that it is one of indirect signs of negative changes in population.

Table 4.1.Tiger numbers and density in model units over years

Model units	# of tigers registered						Tiger density per 100,000 ha					
	1998	1999	2000	2001	2002	2003	1998	1999	2000	2001	2002	2003
Matai	5	5	5	4	6	5	1.96	1.96	1.96	1.57	2.35	1.96
Khor	2	4	4	4	5	4	1.52	3.04	3.04	3.04	3.80	3.04
Tigriny Dom	2	5	5	5	6	7	0.94	2.37	2.37	2.37	2.85	3.32
Khekhtsir	2	2	1	1	1	1	4.43	4.43	2.21	2.21	2.22	2.22
Botchinsky	3	4	6	6	6	4	0.98	1.3	1.95	1.95	1.95	1.3
Total	**14**	**20**	**21**	**20**	**24**	**21**	**1.47**	**2.10**	**2.21**	**2.10**	**2.53**	**2.21**

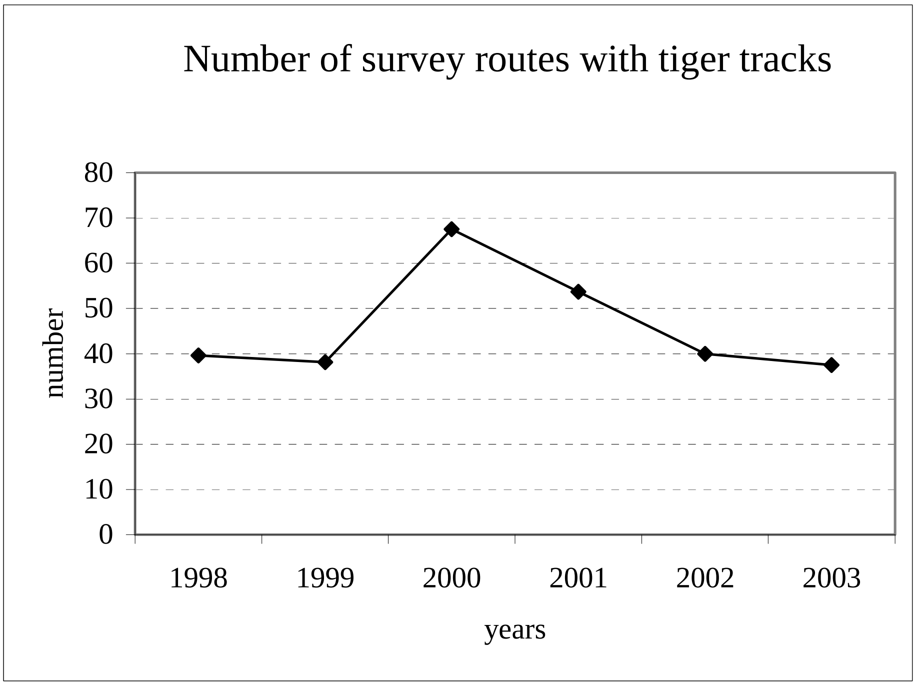
Table 4.2. The number of tiger tracks (no older than 7 days) on survey routes over years

Model units	1st survey						2nd survey					
	1997	1998	1999	2000	2001	2002	1998	1999	2000	2001	2002	2003
Matai	7	5	6	13	23	12	6	4	20	19	4	10
Khor	8	14	15	5	8	16	15	3	3	10	7	4
Tigriny Dom	6	7	6	16	19	19	6	13	8	11	15	23
Khekhtsir	8	3	1	0	0	1	1	4	1	2	3	0
Botchinsky	4	8	7	7	3	4	7	6	6	13	13	6
Total	**33**	**37**	**35**	**41**	**53**	**52**	**30**	**38**	**47**	**55**	**42**	**43**
# of tracks per I tiger during 2 surveys							4.5	3.75	3.90	4.80	3.96	4.52

Table 4.3. Percentage of routes with tiger tracks in February of each year

Model units	1998	1999	2000	2001	2002	2003
Matai	50.0	62.5	33.3	50.0	25.0	37.5
Khor	31.2	11.8	66.7	38.1	38.1	19.0
Tigriny Dom	50.0	35.7	42.8	50.0	64.3	50.0
Khekhtsir	50.0	28.6	85.7	28.6	28.6	14.3
Botchinsky	28.6	35.7	85.7	100	50.0	64.3
Total	**39.6**	**38.1**	**67.5**	**53.7**	**40.0**	**37.5**

Figure 4.1



5. Monitoring of tiger population structure

According to data obtained from model units tiger population structure is becoming worse (Table 5.1, 5.2 and Figure 5.1).

Tiger population structure for the last 6 years looks in the following way: 35.8% of adult males, 32.5% of adult females, 19.2% of cubs and 12.5% of individuals of undetermined sex. We can suppose that the last group consists of subadult tigers, mainly females. And if tiger population in Khabarovsky Krai consists of 60-65 individuals, then there are 19-21 adult females, including 7-8 females with cubs. In last years average litter size was 1.18 cubs per litter, 8-10 cubs are registered every year. As we know that no less than 5 adult tigers died each year and cubs need time to reach the age of puberty, then the reasons of tiger population decrease are explainable.

Data indicates the following:

1. Continued decrease of cubs percentage in tiger population from 28.6% in 1998 to 9.5% in 2003 (by 66.8%), that is 11.1% on average per each year. Annual deaths of litters indicate that environmental conditions are not favorable for cubs' survival.
2. During the last 5 years the number of females with cubs decreased from 25% in 1999 to 4.8% in 2003.
3. In winter 2002-2003 sex ratio between adult males and adult females changed in favor of females. The changes could probably be attributed to sex determining of animals whose sex had been previously not identified.
4. The percentage of females without cubs was increasing and reached 38.5% that in comparison with 5% in 1999 looks disastrous.

Thus the situation with tiger reproduction is unfavorable.

Table 5.1. Tiger population structure, 2002-2003

Model units	Males	Females without cubs	Females with cubs	Cubs	Undetermined sex	Total
Matai	1	2	0	1	1	5
Khor	2	2	0	0	0	4
Tigriny Dom	3	2	1	1	0	7
Khekhtsir	0	1	0	0	0	1
Botchinsky	1	1	0	0	2	4
Total	**7**	**8**	**1**	**2**	**3**	**21**

Table 5.2. Changes in tiger population structure in all model units over years

Sex and age	1997/98		1998/99		1999/00		2000/01		2001/02		2002/03	
	ind	%	ind	%	ind	%	ind	%	ind	%	ind	%
Males	4	28.6	6	30.0	8	38.1	8	40.0	10	41.7	7	33.3
Females without cubs	3	21.4	1	5.0	2	9.5	3	15.0	5	20.8	8	38.1
Females with cubs	2	14.3	5	25.0	4	19.0	3	15.0	2	8.3	1	4.8
Cubs	4	28.6	5	25.0	5	23.9	4	20.0	3	12.5	2	9.5
Undetermined sex	1	7.1	3	15.0	2	9.5	2	10.0	4	16.7	3	14.3
Total	**14**	**100**	**20**	**100**	**21**	**100**	**20**	**100**	**24**	**100**	**21**	**100**

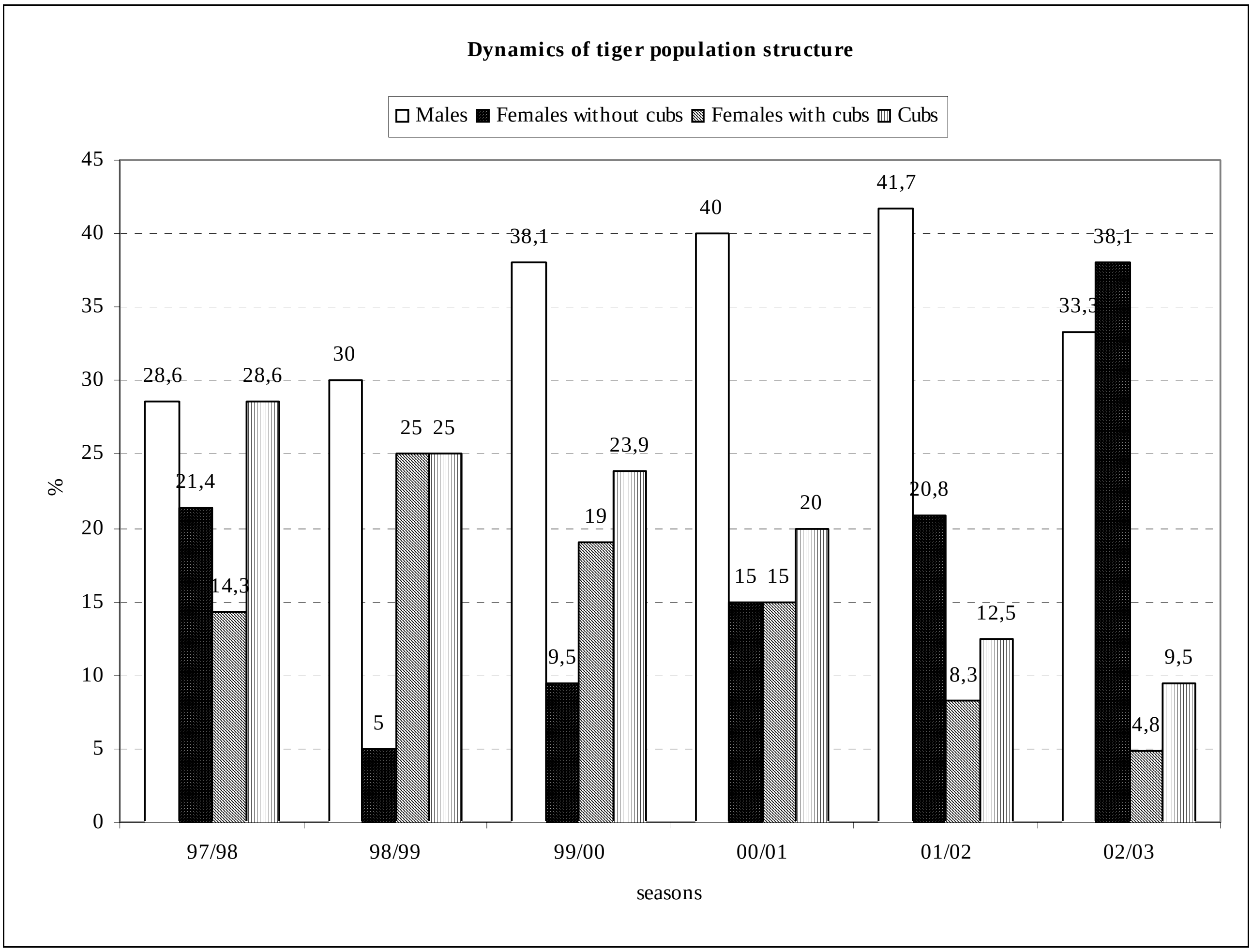


Table 5.3. Average litter size in model units over years

Model units	Average litter size						
	1996	1998	1999	2000	2001	2002	2003
Matai	-	2.0	1.0	2.0	0	0	0
Khor	-	-	-	-	1.0	1.0	0
Tigriny Dom	-	-	1.0	1.0	1.0	1.0	1
Khekhtsir	-	1.0	1.0	-	0	0	0
Botchinsky	-	-	1.0	1.0	2.0	0	0
Total	**1.67**	**1.5**	**1.0**	**1.25**	**1.33**	**1.0**	**1.0**

Based on the information given in Table 5.3 average litter size is minimal. By the end of winter 2002-2003 only 0.22 cubs per 1 female had remained. In previous years this index was 0.8-0.83. Sharp decrease started in winter 2001-2002 (0.67). Slight increase of litter size was observed in 2000 and 2001, it coincided with high wild boar density. Then with wild boar numbers declining litter size decreased as well.

Six year mean number of adult females without cubs amounts to 61.5% of total females.
Other females either had lost their cubs by February or were not impregnated. Probably such situation is characteristic of population depression.

Table 5.4. Number of cubs per 1 adult female over years

Females and cubs	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
# of adult females	5	6	6	6	7	9
# of litters	2	4	3	3	2	1
Females without cubs, %	60.0	66.7	50.0	50.0	71.4	88.9
Total number of cubs	4	5	5	4	3	2
Cubs without female	1	1	1	0	1	1
Total number of cubs per 1 female	0.8	0.83	0.83	0.67	0.43	0.22
Number of cubs from litters per 1 female	0.6	0.67	0.67	0.67	0.29	0.11

6. Monitoring of tiger range

While collecting information about changes of tiger range in 2002-2003 it was revealed that tigers became less common in Komsomolskiy Raion, tigers did not cross highway from Vladivostok to Khabarovsk and tigers were not found in upper Chuken, Kafen and Katen, where they were common in previous years. Probably tiger range is shrinking but more reliable information will be obtained after data of ungulate sweep survey are processed. Three-toed female still lives in Bolshoy Khekhtsir ridge, another female is still residing in Tagemu river basin (tributary of Sukpai river in Lazo Raion). No males and litters were found in these areas.

7. Monitoring of tiger mortality

We know the following cases of tiger deaths happened in 2002-2003:

1. In Mataisky model unit two cubs were found. They were emaciated and one of them died on the way to rehabilitation center.
2. In the other part of Mataisky model unit one more cub traveled along roads searching for prey and was poached.
3. In addition to three tiger cubs removed from the wild mentioned above on December 9, 2002 militiamen seized skin of tiger cub in Bikin village. Place, where cub was killed, is unknown.
4. Adult male tiger was found dead in Chuken river basin. Cause of death (according to the conclusion of veterinary service) – fluoroacetate barium poisoning.
5. Adult male was poached in February 2003 in Komsomolskiy Raion (unofficial information).
6. Adult male was found drowned in Khor river (Razbity creek area) in winter 2001.
7. In 1998 nearly at the same place adult male was also found drowned. He had bullet wounds.

In total according to data obtained in winter 2002-2003 6 tigers died, and 49 tigers were found dead for 6 years of monitoring program implementation (Table 7.1).

In addition to the abovementioned cases we suppose that tigress in Matai model unit was poached, because after emaciated cubs were found, local citizen from an adjacent raion was detained while setting up a self-made self-firing gun on a tiger trail.

Thus, data provided in last report were corrected and it is normal because it is not always possible to get complete information on tiger death in the year of survey. Such kind of information becomes available some time later, when it becomes impossible to find accusatory evidence. Due to this fact we can not provide the complete information on tiger mortality for this year.

Table 7.1. Data on tiger mortality over 6 last field seasons

Cause of death	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	Total	
							ind	%
Official shots	1	0	2	0	1	1	5	10.2
Natural death	1	0	1	3	0	1	6	12.2
Cannibalism	5	0	0	0	3	0	8	16.3
Poaching	3	2	5	5	11	4	30	61.3
Total	**10**	**2**	**8**	**8**	**15**	**6**	**49**	**100**

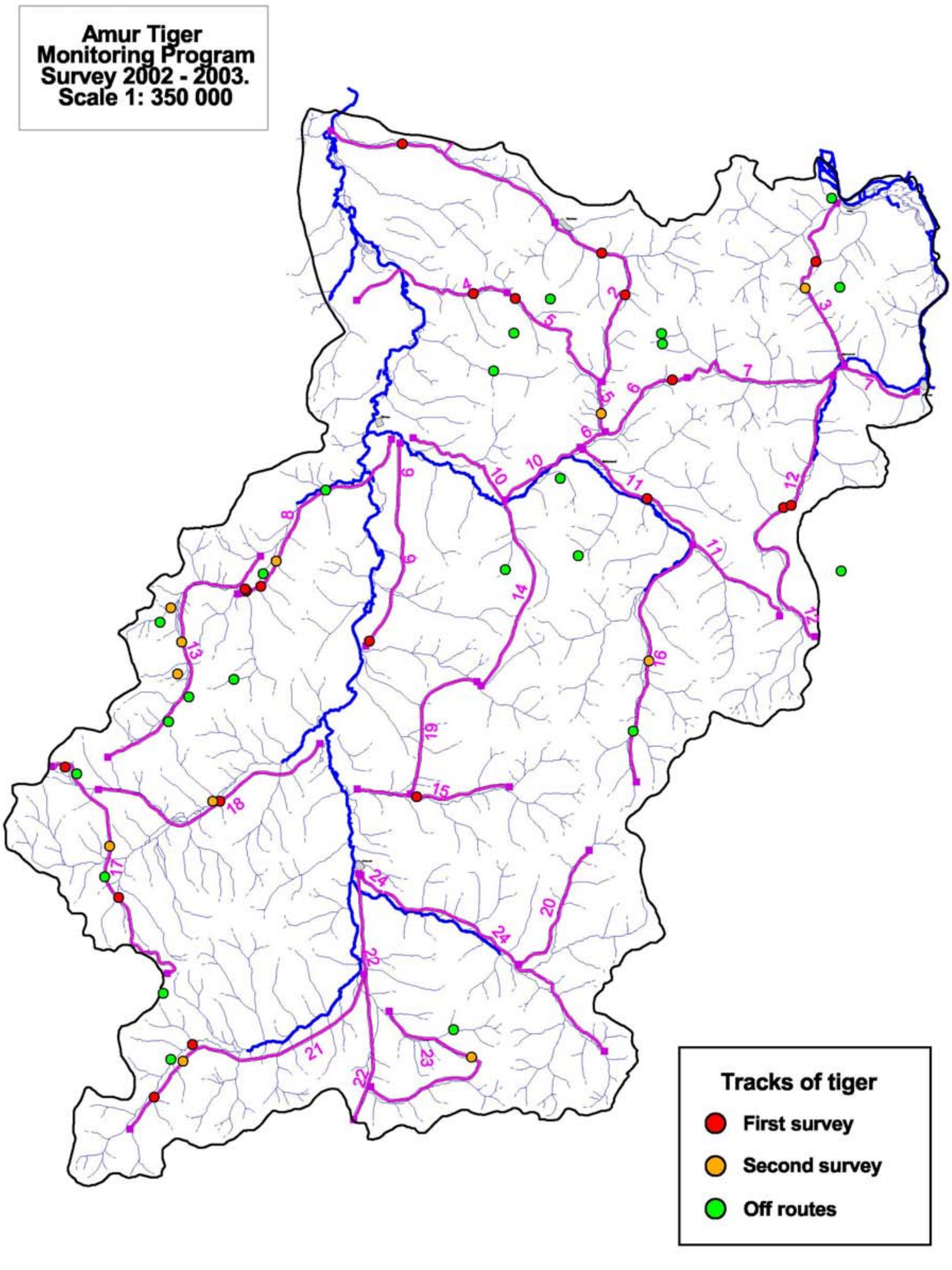
8. Conclusions and recommendations

In addition to conclusions given in 5-year report last year we can add the following:

1. Good habitat conditions for wild ungulates and low success of hunting last years caused slight increase of red deer, roe deer and wild boar populations. Sika deer range is extending. Our prognosis, which we gave two years ago, proved to be correct which confirms that monitoring methods are correct. Nevertheless, it is too early to talk about stable positive trends in ungulate populations and all recommendations on recovery of tiger prey species remain valid.
2. Tiger reproduction is still decreasing, the number of females with cubs and litter size are at the lowest level. Cubs died in the first year and this may be caused by low density of wild boars. Additionally females with cubs are more vulnerable for poachers because they stay in confined areas.
3. A change in sex ratio toward increase of females should be considered as positive. This change most probably could be attributed to maturing of young animals whose sex earlier had not been identified Moreover, for the first time since the monitoring program start almost in all model units couples (adult male and adult female) were observed. We suppose that the number of litters will increase next year. In this connection the lack of prey resources may cause the situation when predators approach settlements searching for food. This may result in conflicts between tiger and people.
4. Decrease of tiger numbers by 12.5% in model units is probably temporary, because most of model units are situated in the best current tiger habitat. Nevertheless, the information about decrease of tiger numbers in marginal areas of its range raises a red flag, because it may be the sign of range shrinking.
5. Tiger mortality due to different reasons remains high. In average we get information about 8 tiger deaths each year, most of these tigers are poached. If to take into account that in Khabarovsk part of range the same number of cubs survives, then we can suppose that the balance is not in the favor of population conservation.

Detailed recommendations on conservation are given in 5-year monitoring report and they are still valid.

Model unit "Matayski"



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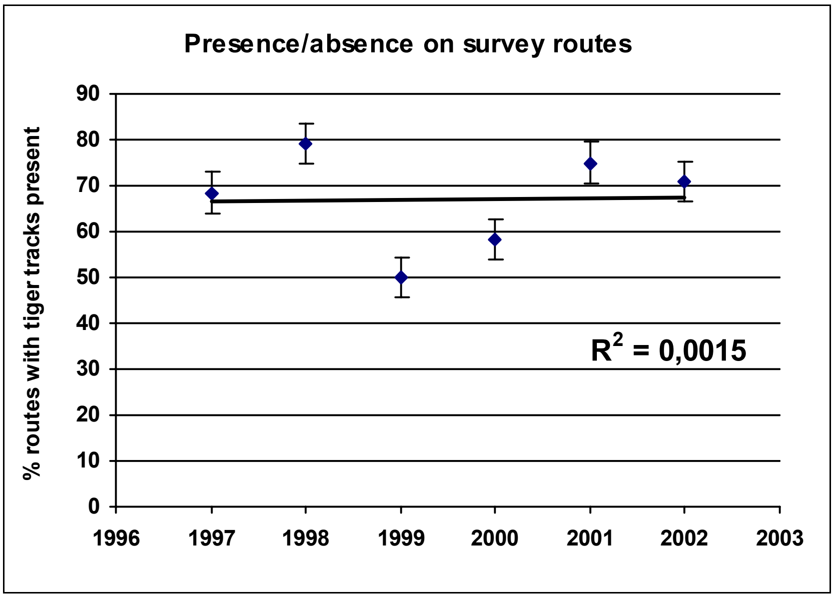
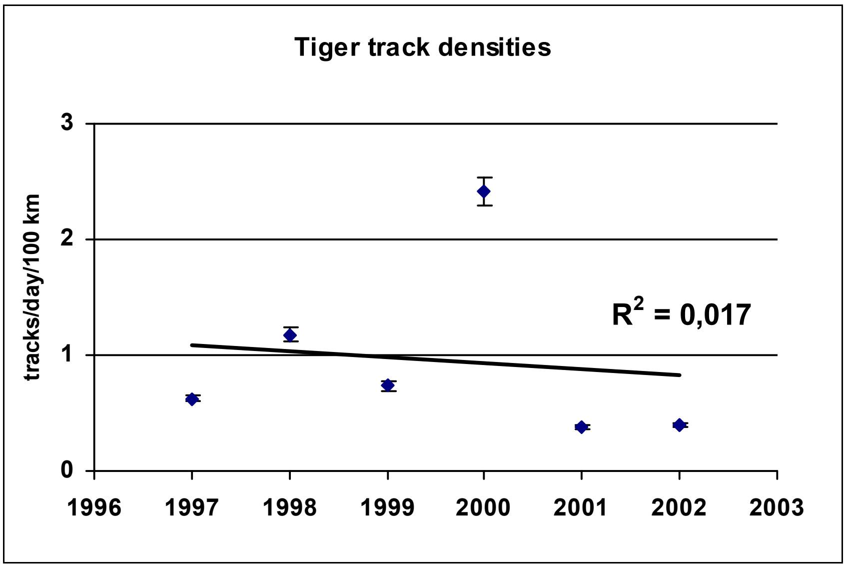
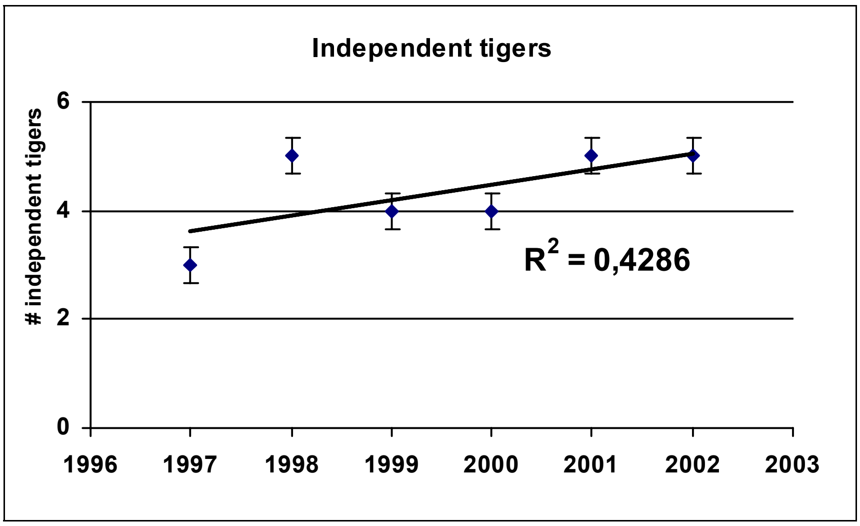

Presence/absence on survey routes
% routes with tiger tracks present
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,0015


Tiger track densities
tracks/day/100 km
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,017

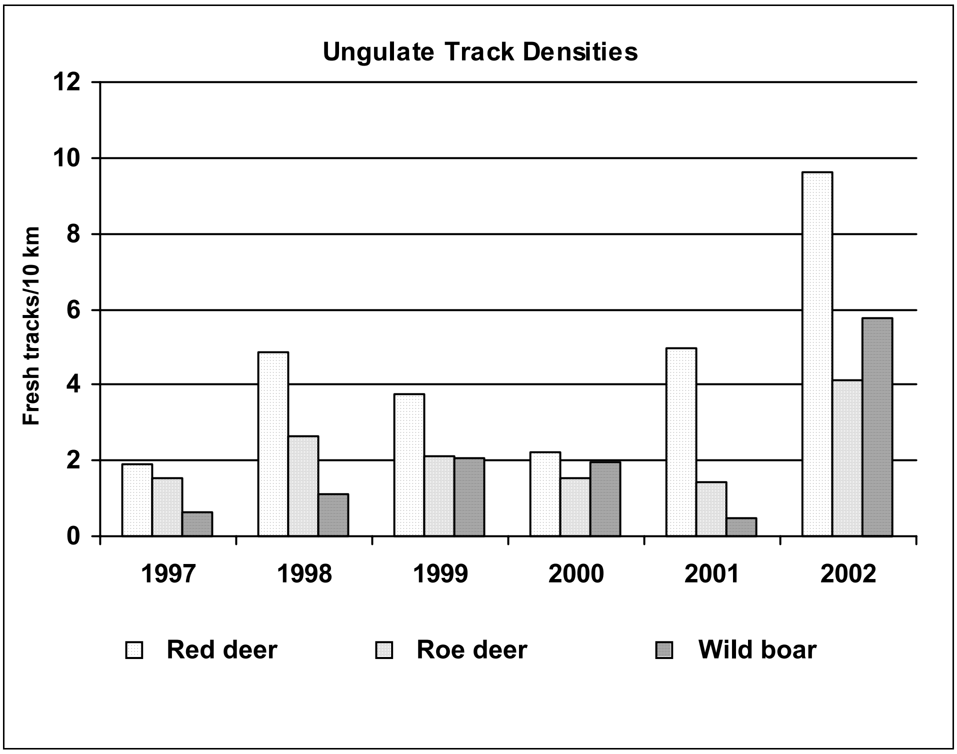

Independent tigers
independent tigers
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,4286

Number of tigers, by age class and sex (for adults only) in “Matai” Amur tiger monitoring site

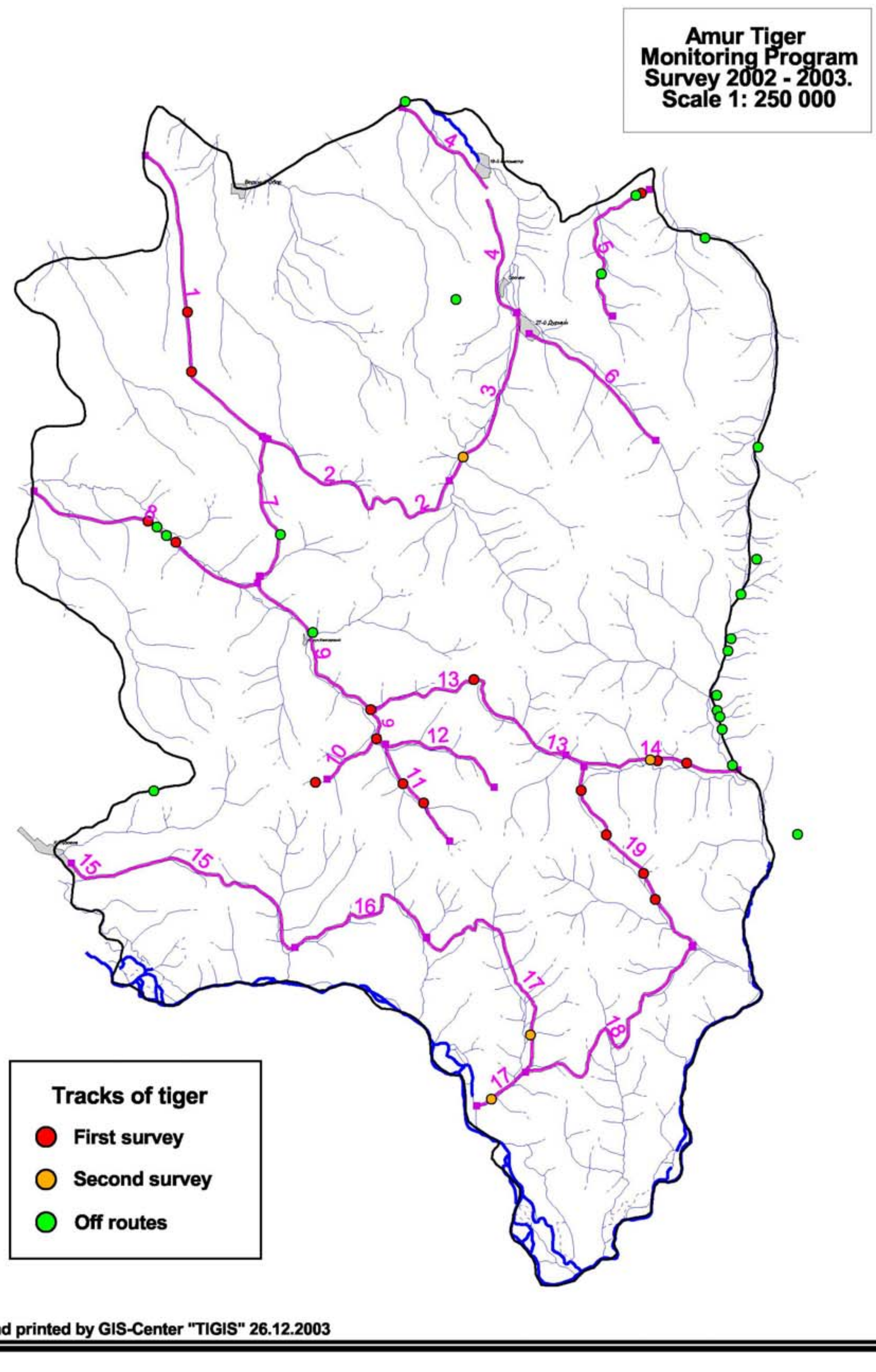
Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	2	0	0	3	0	3	3	6
1998	0	2	0	2	0	1	2	3	3
1999	1	1	0	2	2	0	2	2	4
2000	1	2	0	0	2	0	3	3	5
2001	2	2	1	0	1	1	5	6	7
2002	1	3	0	0	4	0	4	4	8

Mean track density (tracks less than 24 hours) of ungulates in “Matai” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	24	1.91	2.32	1.53	2.29	0	0	0.66	1.22
1998	24	4.85	5.26	2.62	3.08	0	0	1.11	1.52
1999	24	3.76	4.45	2.1	2.02	0	0	2.05	2.7
2000	24	2.21	2.57	1.53	1.3	0	0	1.94	3.34
2001	24	4.96	9.06	1.43	1.61	0	0	0.45	0.94
2002	24	9.63	9.4	4.11	5.91	0.05	0.34	5.77	5.79
Total mean		4.55	5.51	2.22	2.7	0.01	0.06	2	2.59



Model unit "Khorski"



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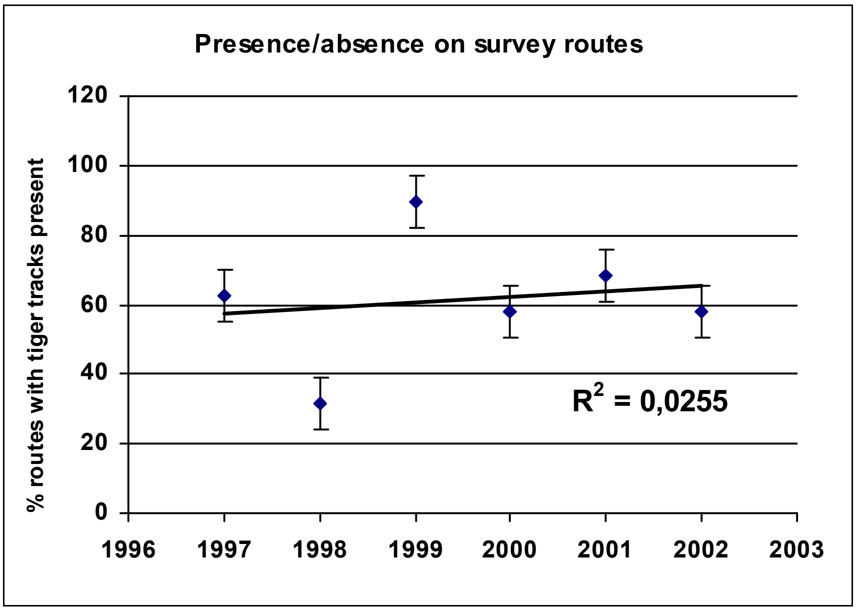
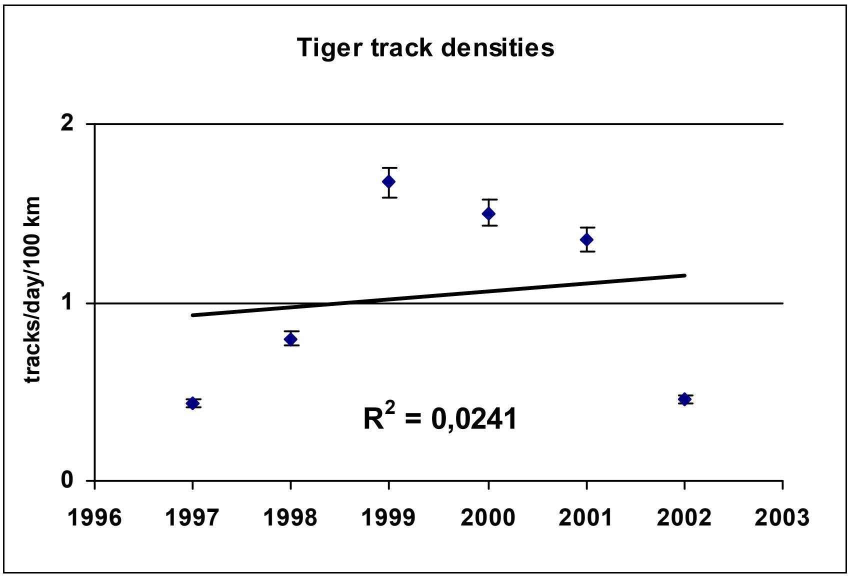
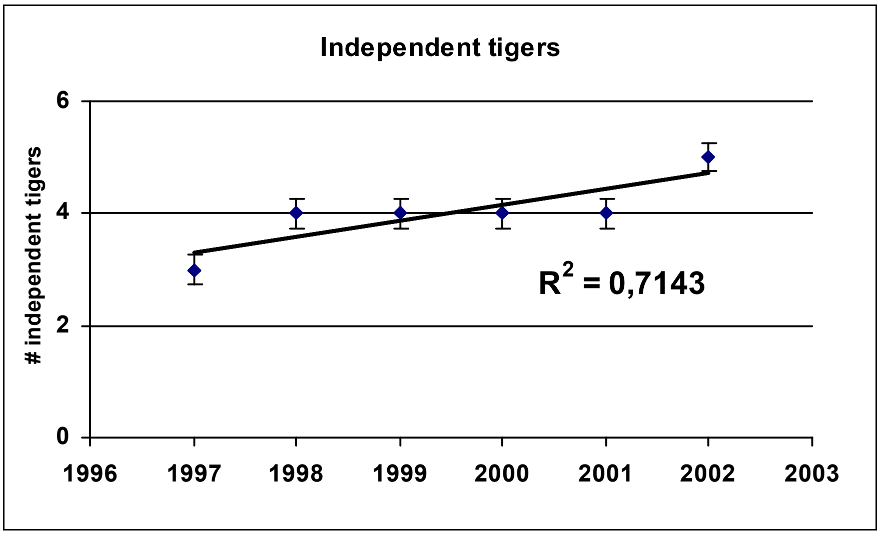

Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,0255


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,0241

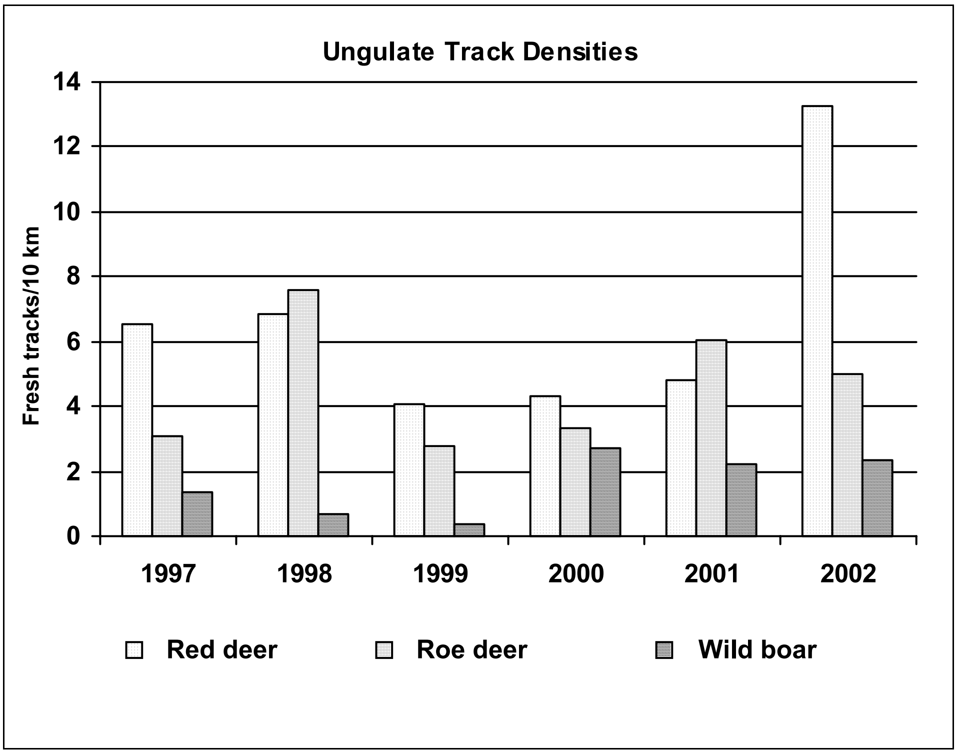

Independent tigers
independent tigers
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,7143

Number of tigers, by age class and sex (for adults only) in “Khor” Amur tiger monitoring site

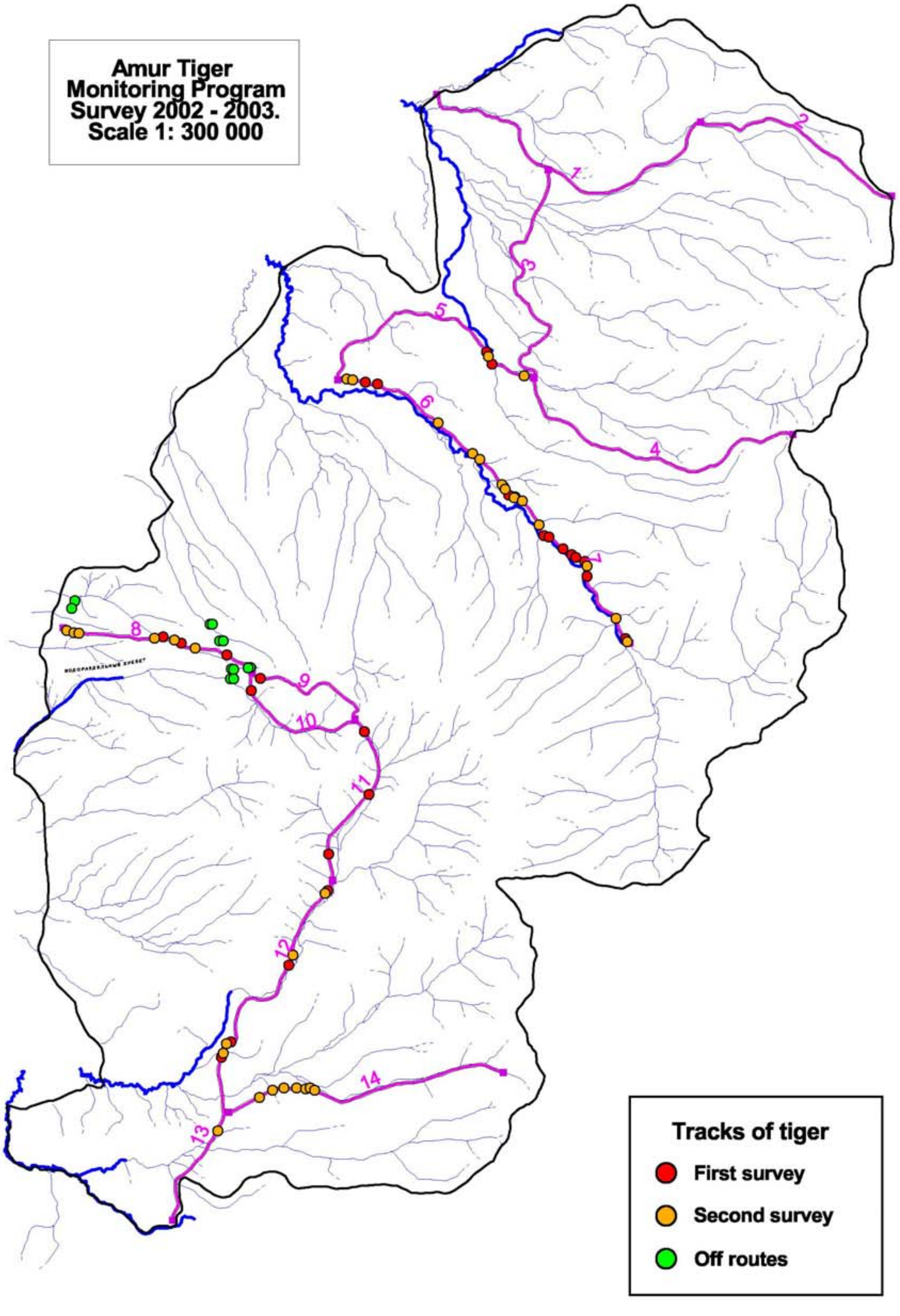
Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	2	1	0	0	1	0	3	3	4
1998	2	2	0	0	2	0	4	4	6
1999	2	2	0	0	0	0	4	4	4
2000	2	2	0	0	1	0	4	4	5
2001	3	1	0	0	1	0	4	4	5
2002	3	2	0	0	0	0	5	5	5

Mean track density (tracks less than 24 hours) of ungulates in “Khor” Amur tiger monitoring site for 6 years

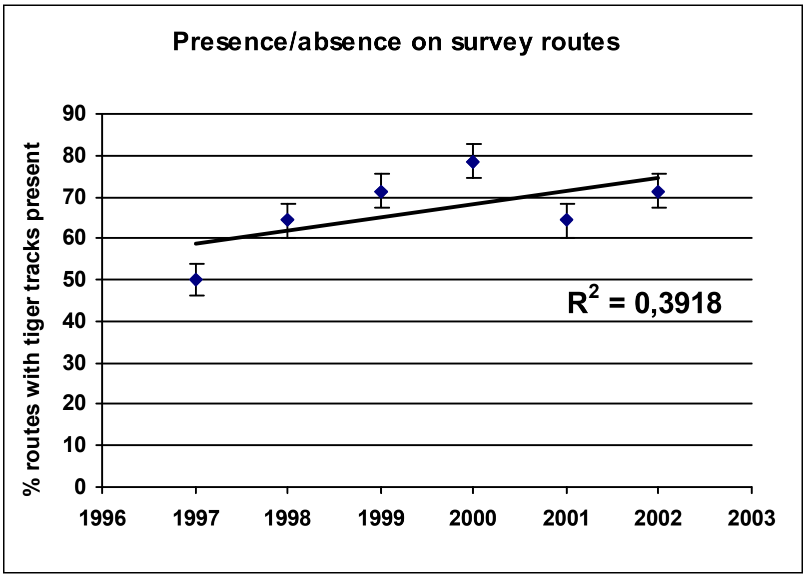
Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	19	6.55	7.3	3.1	3.9	0	0	1.36	2.84
1998	19	6.82	7.51	7.6	9.11	0	0	0.66	1.39
1999	19	4.09	5.77	2.8	4.02	0	0	0.38	1.11
2000	19	4.29	5.34	3.35	4.11	0	0	2.73	4.99
2001	19	4.83	6	6.07	8.12	0	0	2.21	6.36
2002	19	13.28	13.11	5.01	9.98	0	0	2.33	5.24
Total mean		6.64	7.5	4.66	6.54	0	0	1.61	3.66



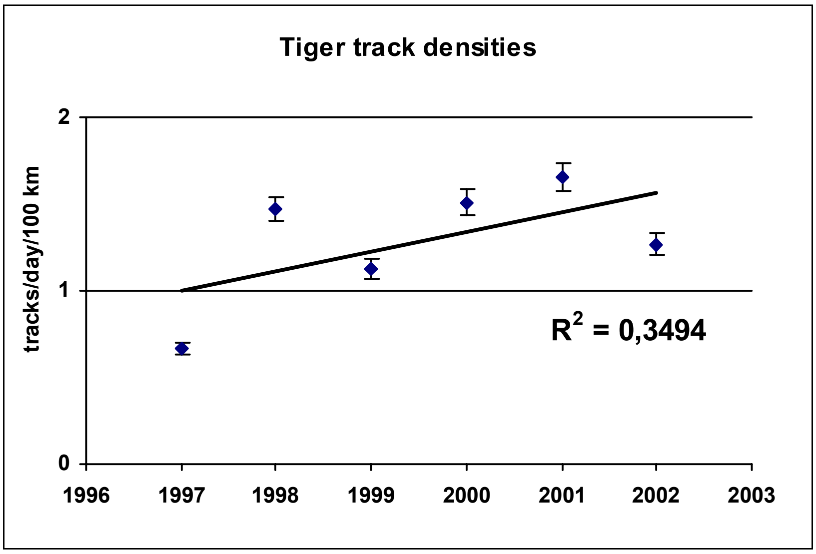
Model unit "Tigroviy dom"



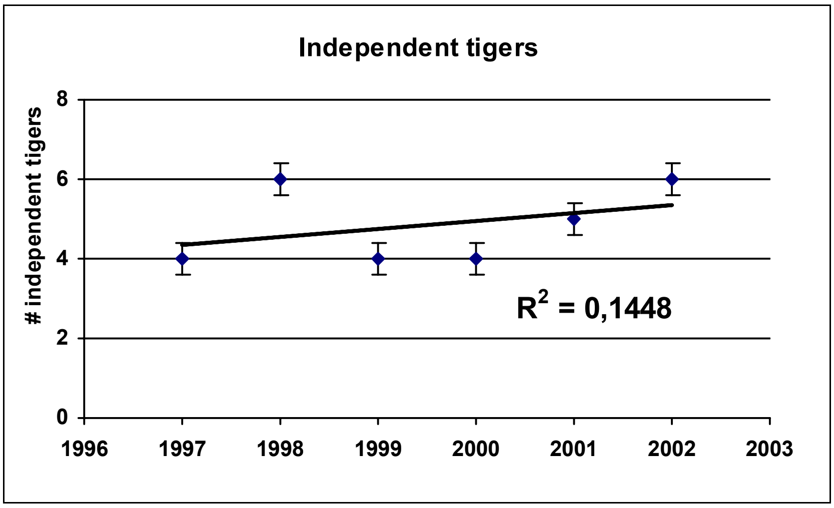
Designed and printed by GIS-Center "TIGIS" 26.12.2003



Presence/absence on survey routes
% routes with tiger tracks present
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,3918



Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,3494



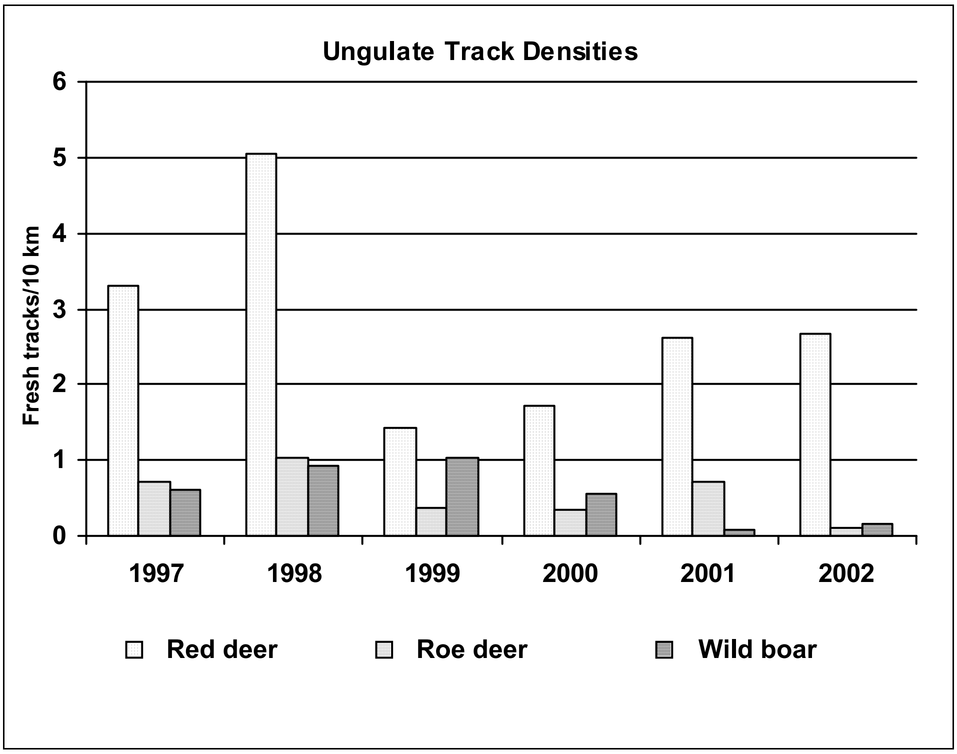
Independent tigers
independent tigers
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R^2 = 0,1448

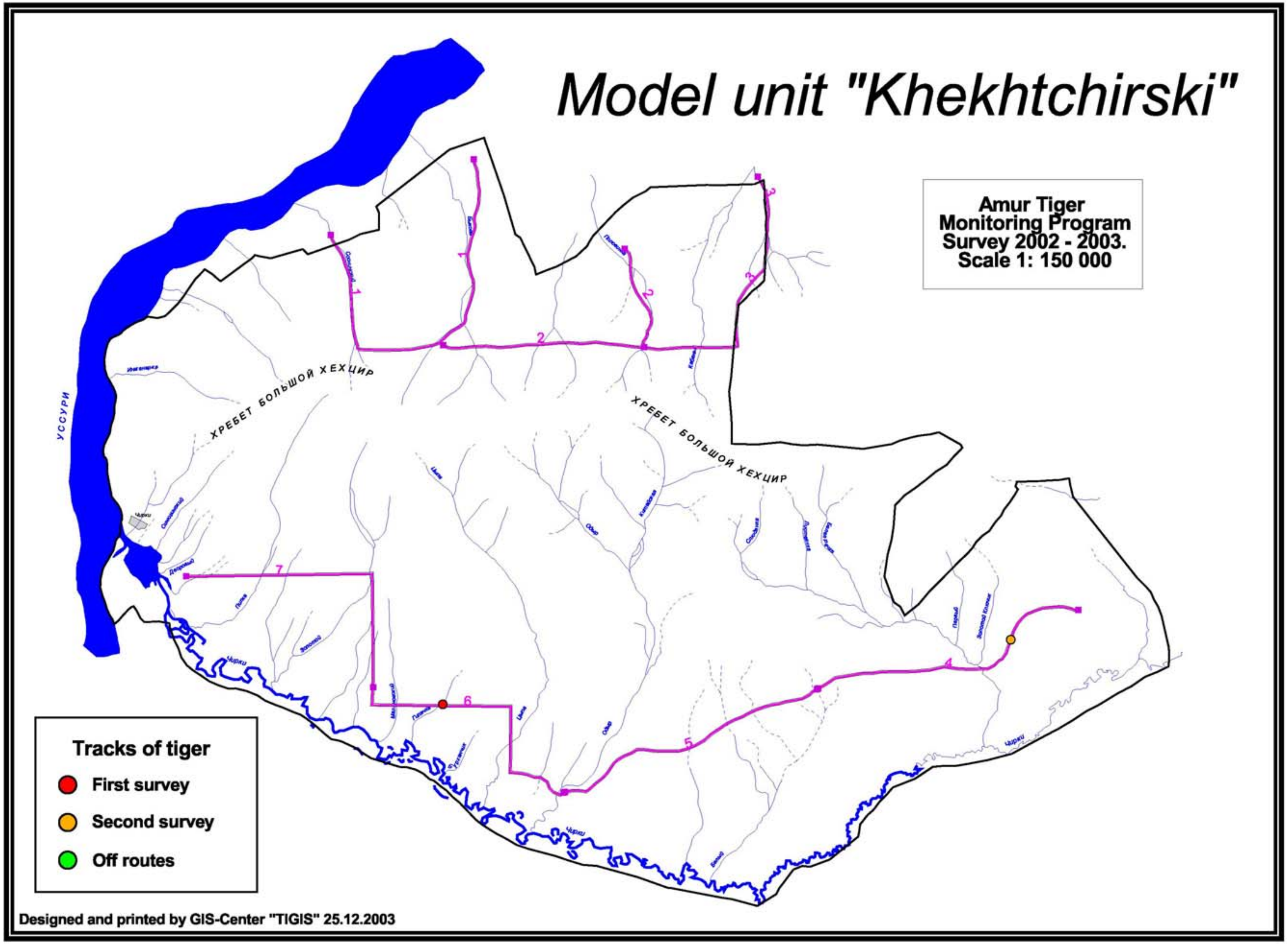
Number of tigers, by age class and sex (for adults only) in "Tigriny Dom" Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	2	0	0	1	0	0	2	2	2
1998	2	0	0	2	0	0	2	2	2
1999	3	1	0	0	1	0	4	4	5
2000	2	1	0	1	1	0	3	3	4
2001	3	2	0	0	1	0	5	5	6
2002	3	3	0	0	1	0	6	6	7

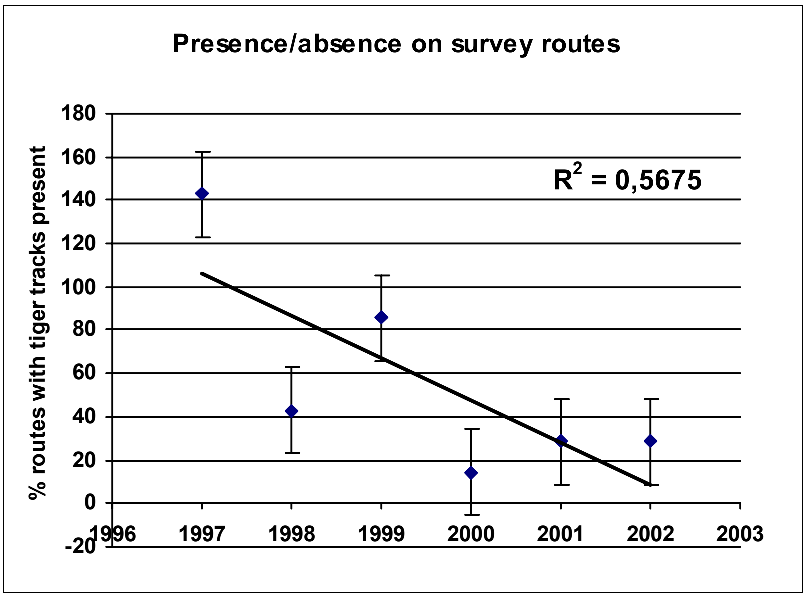
Mean track density (tracks less than 24 hours) of ungulates in "Tigriny Dom" Amur tiger monitoring site for 6 years

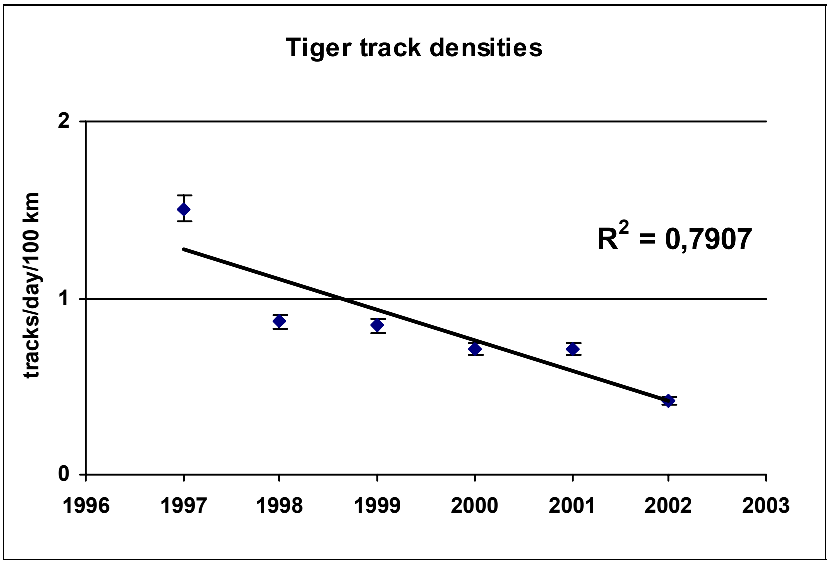
Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	14	3.29	6.46	0.72	1.18	0	0	0.6	1.83
1998	14	5.06	4.62	1.04	2.69	0	0	0.93	2.25
1999	14	1.43	1.8	0.38	1.11	0	0	1.03	1.62
2000	14	1.72	2.32	0.34	0.71	0	0	0.57	1.11
2001	14	2.61	3.33	0.72	1.63	0	0	0.09	0.32
2002	14	2.67	3.01	0.1	0.27	0	0	0.16	0.41
Total mean		2.8	3.59	0.55	1.26	0	0	0.56	1.26

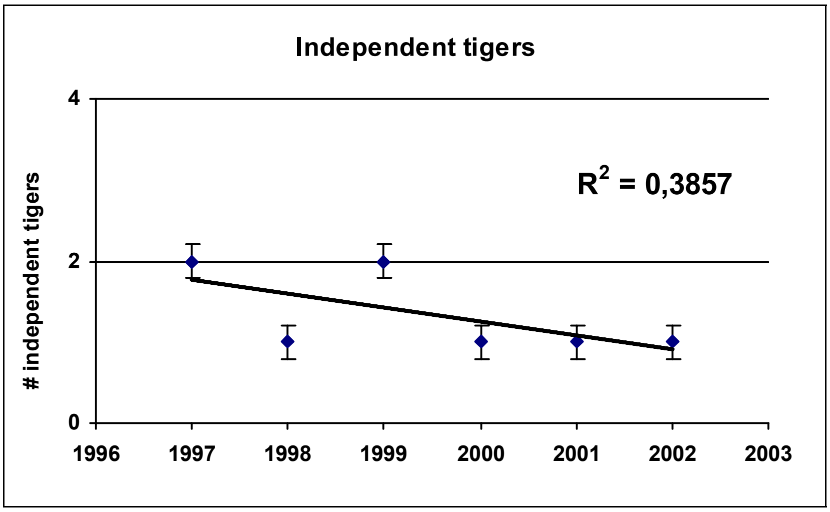




Model unit "Khekhtchirski"
Amur Tiger
Monitoring Program
Survey 2002 - 2003.
Scale 1: 150 000
УССУРИ
ХРЕБЕТ БОЛЬШОЙ ХЕХЦИР
ХРЕБЕТ БОЛЬШОЙ ХЕХЦИР
Tracks of tiger
First survey
Second survey
Off routes
Designed and printed by GIS-Center "TIGIS" 25.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
180
160
140
120
100
80
60
40
20
0
-20
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,5675


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,7907

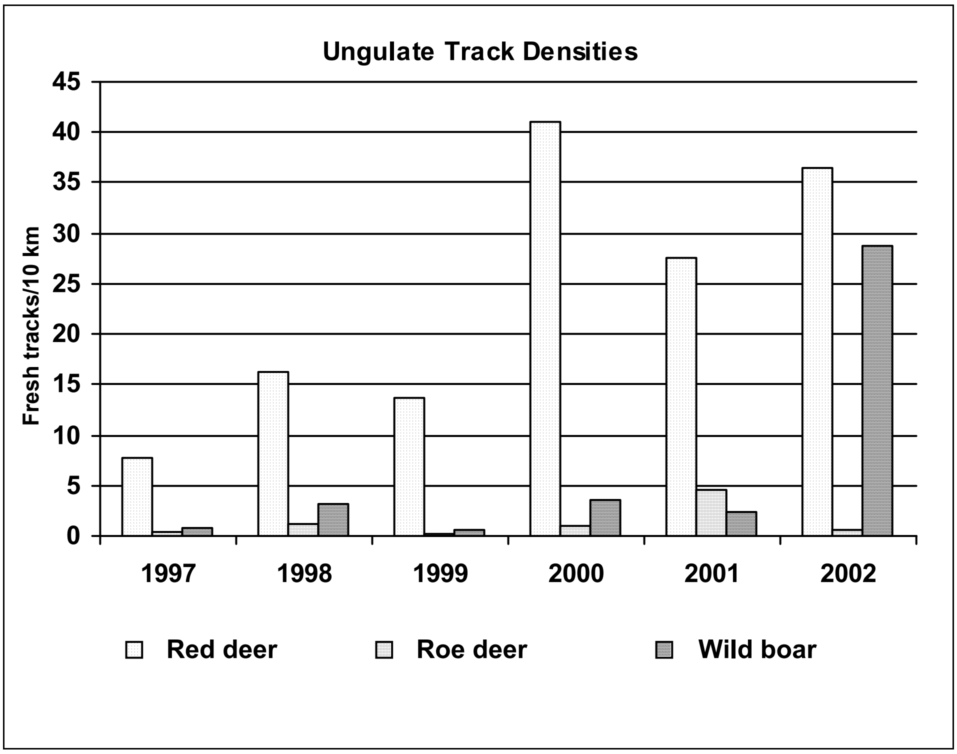

Independent tigers
independent tigers
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R2 = 0,3857

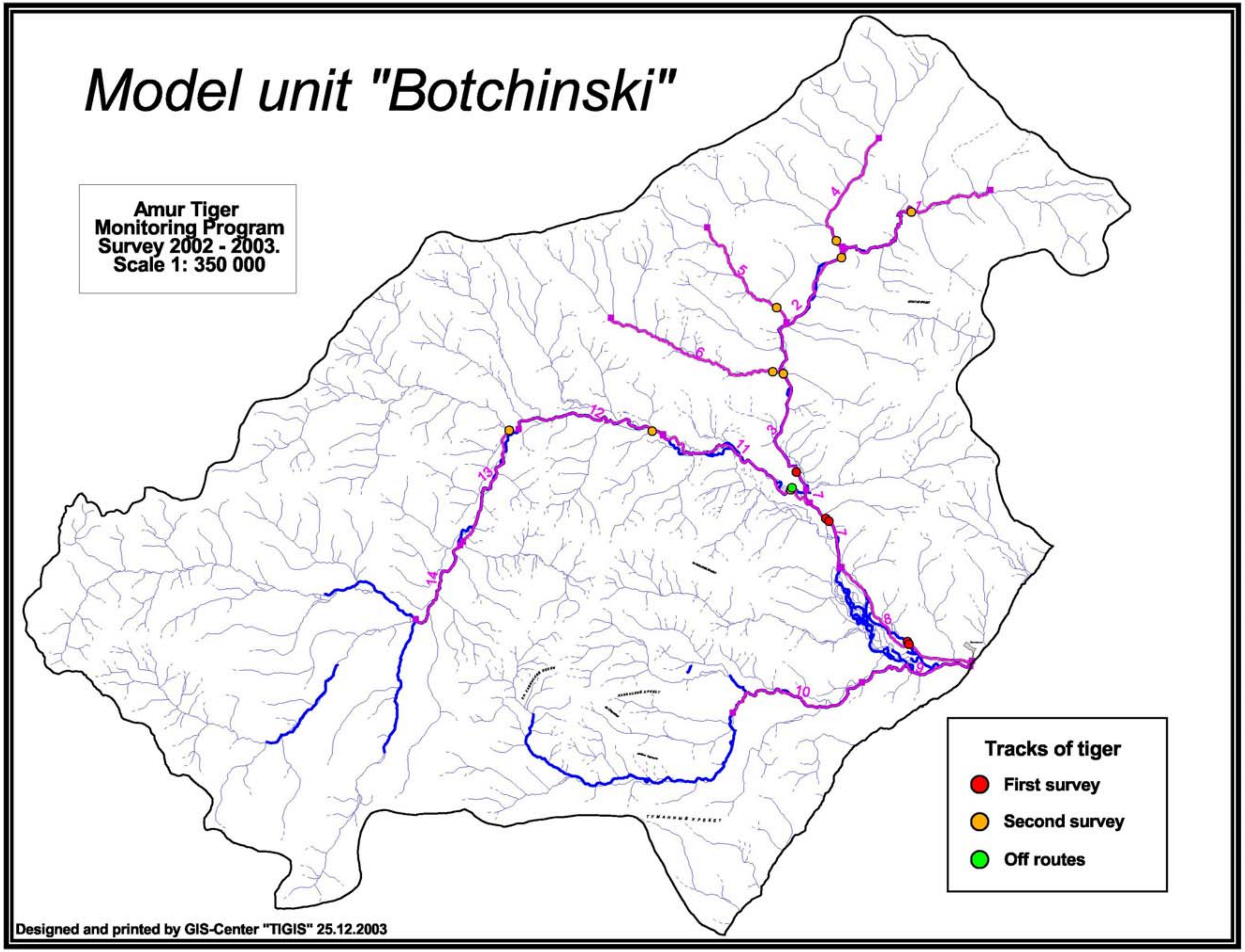
Number of tigers, by age class and sex (for adults only) in “Bolshe-Khekhtsirsky Zapovednik” Amur tiger monitoring site

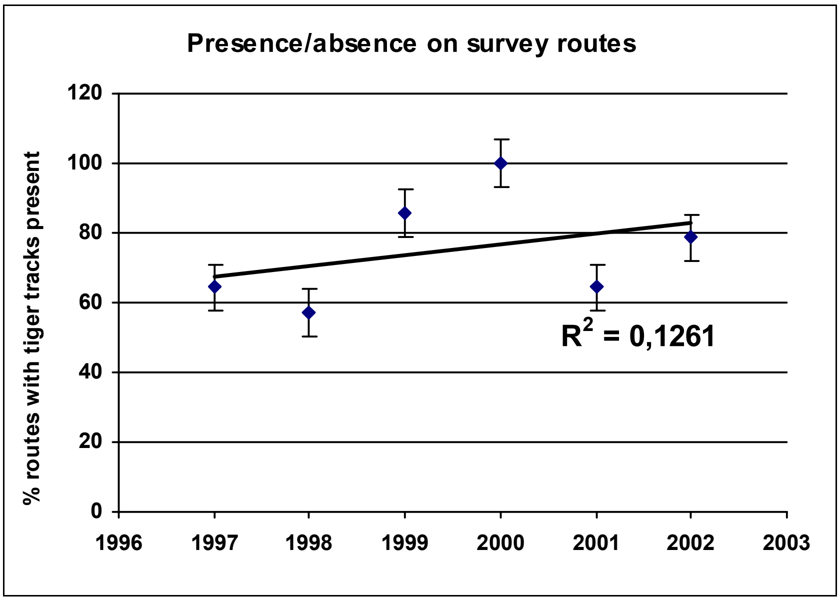
Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	1	0	0	0	0	2	2	2
1998	0	1	0	0	1	0	1	1	2
1999	1	1	0	0	0	0	2	2	2
2000	0	1	0	0	3	0	1	1	4
2001	0	1	0	0	0	0	1	1	1
2002	0	1	0	0	0	0	1	1	1

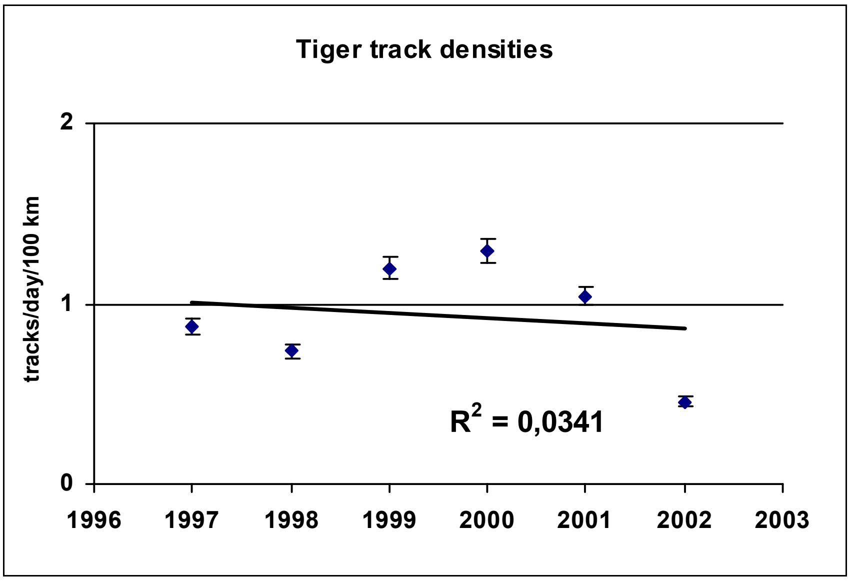
Mean track density (tracks less than 24 hours) of ungulates in “Bolshe-Khekhtsirsky Zapovednik” Amur tiger monitoring site for 6 years

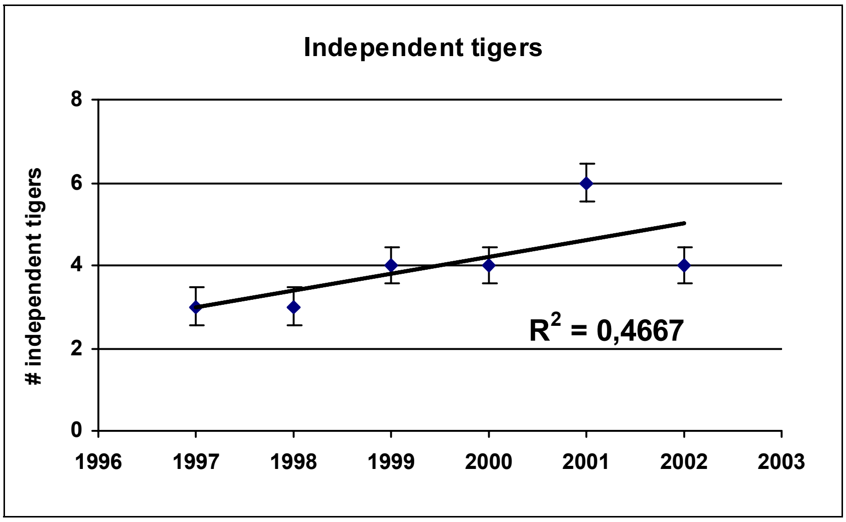
Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	7	7.8	8.82	0.45	0.4	0	0	0.8	1.65
1998	7	16.29	15.96	1.27	1.9	0	0	3.16	4.95
1999	7	13.65	13.1	0.16	0.59	0	0	0.61	1.51
2000	7	40.97	63.13	0.92	2.07	0	0	3.52	6.45
2001	7	27.51	27.24	4.53	8.47	0	0	2.46	5.98
2002	7	36.57	32.9	0.68	1.42	0	0	28.82	55.14
Total mean		23.8	26.86	1.34	2.47	0	0	6.56	12.61




Model unit "Botchinski"
Amur Tiger
Monitoring Program
Survey 2002 - 2003.
Scale 1: 350 000
Tracks of tiger
First survey
Second survey
Off routes
Designed and printed by GIS-Center "TIGIS" 25.12.2003


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,1261


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,0341

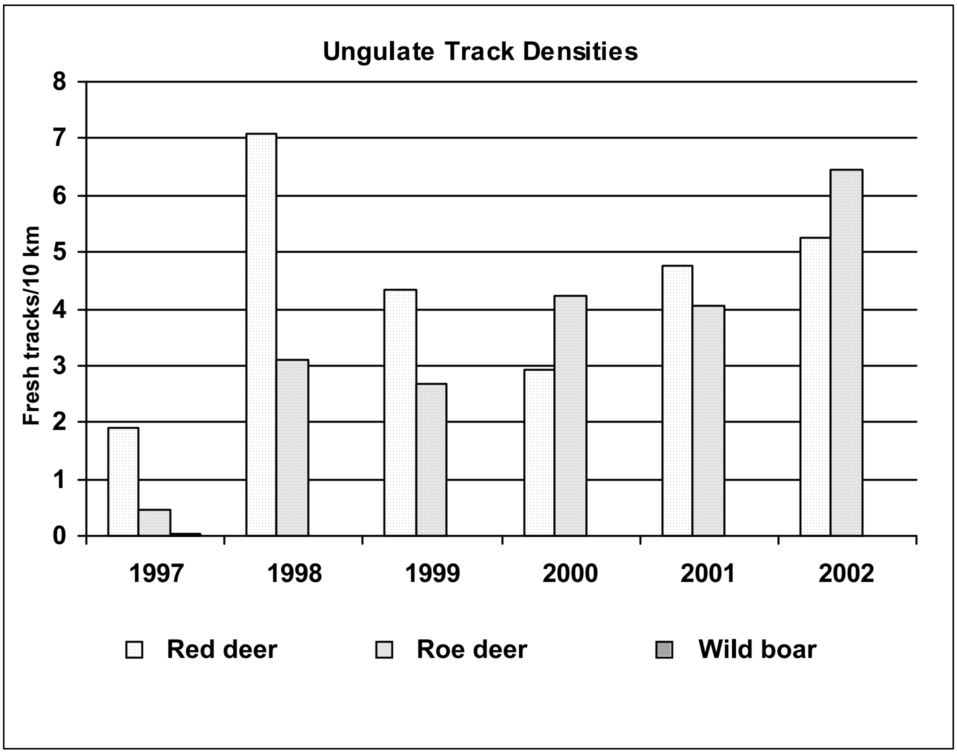

Independent tigers
independent tigers
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
2003
R² = 0,4667

Number of tigers, by age class and sex (for adults only) in “Botchinsky Zapovednik” Amur tiger monitoring site

Year	Age						Total		
	Adult								
	Males	Females	Unknown	Subadult	Cubs	Unknown age	Total adult tigers	Total independent tigers	Total (all tigers)
1997	1	2	0	0	1	0	3	3	4
1998	1	0	0	1	1	0	1	1	2
1999	2	2	0	0	2	0	4	4	6
2000	2	1	0	1	2	0	3	3	5
2001	2	1	2	1	0	2	5	7	7
2002	1	1	0	2	0	0	2	2	2

Mean track density (tracks less than 24 hours) of ungulates in “Botchinsky Zapovednik” Amur tiger monitoring site for 6 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	14	1.89	1.89	0.45	1	0	0	0.03	0.15
1998	14	7.07	7.59	3.11	4.56	0	0	0	0
1999	14	4.33	3.09	2.69	3.22	0	0	0	0
2000	14	2.92	3.59	4.24	4.99	0	0	0	0
2001	14	4.76	3.73	4.05	4.03	0	0	0	0
2002	14	5.26	4.35	6.44	6.66	0	0	0	0
Total mean		4.37	4.04	3.5	4.08	0	0	0	0.02



WILDLIFE CONSERVATION SOCIETY

The Wildlife Conservation Society works in 52 countries around the world to conserve wildlife and the ecosystems upon which they depend by applying innovative scientific and field-based solutions to critical environmental problems