A MONITORING PROGRAM FOR THE AMUR TIGER

FIFTH-YEAR REPORT: 2001-2002

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

Funding Provided by:

The Save-the-Tiger Fund
National Fish and Wildlife Foundation/Exxon Corporation

FUNDING FOR YEAR 5 PROVIDED BY A GRANT TO

THE WILDLIFE CONSERVATION SOCIETY

FROM

THE SAVE-THE-TIGER FUND
NATIONAL FISH AND WILDLIFE FOUNDATION
EXXON CORPORATION

Previous Sponsors include:

Save the Tiger Fund
The Tiger Rhinoceros Conservation Fund, U.S. Fish and Wildlife Service
World Wide Fund For Nature, U.S.

PROJECT COORDINATORS:

Overall Coordinator:
Miquelle, Dale G., Wildlife Conservation Society, Russian Far East Program

Khabarovski Krai Coordinator
Dunishenko, Yuri. M. A, All Russia Research Institute of Wildlife Management, Hunting, and Farming

Primorski Krai Coordinators:
Abramov, Vladimir K., Ussurisk Zapovednik
Aramilev, Vladimir V., Institute for Sustainable Use of Renewable Resources
Fomenko, Pavel. V. WWF, Russian Far East
Nikolaev, Igor G., Institute of Biology and Soils, Far Eastern Branch Russian Academy of Sciences
Pikunov, Dimitri G., Institute of Geography, Far Eastern Branch of the Russian Academy of Sciences
Salkina, G. P., Lazovski State Zapovednik
Smirnov, E. N., Sikhote-Alin Biosphere State Zapovednik

Data entry, Translations, Report Editing, and Project Management
Katerina Nikolaeva

TABLE OF CONTENTS

A MONITORING PROGRAM FOR THE AMUR TIGER

FIFTH-YEAR REPORT: 2001-2002 WINTER

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 2001-2002 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).

In contrast to previous years, for the first time all three indicators of tiger abundance suggest that tiger numbers may be declining. A trend analysis using track abundance data for the past 4 years only, demonstrates a significant decline in this indicator (Table 12c: $r^2 = 0.92$, P = 0.04). Other indicators (presence of tiger tracks on routes and expert assessments of tiger numbers) are not statistically significant, but both indicate a downward trend.

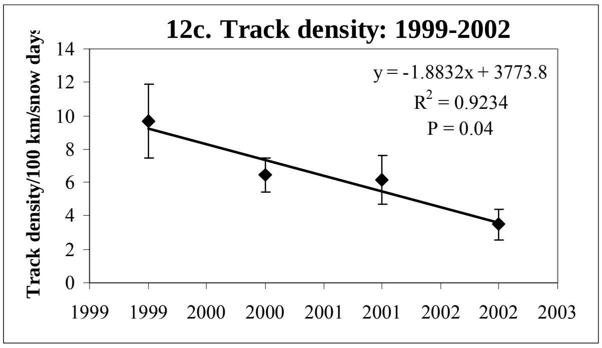
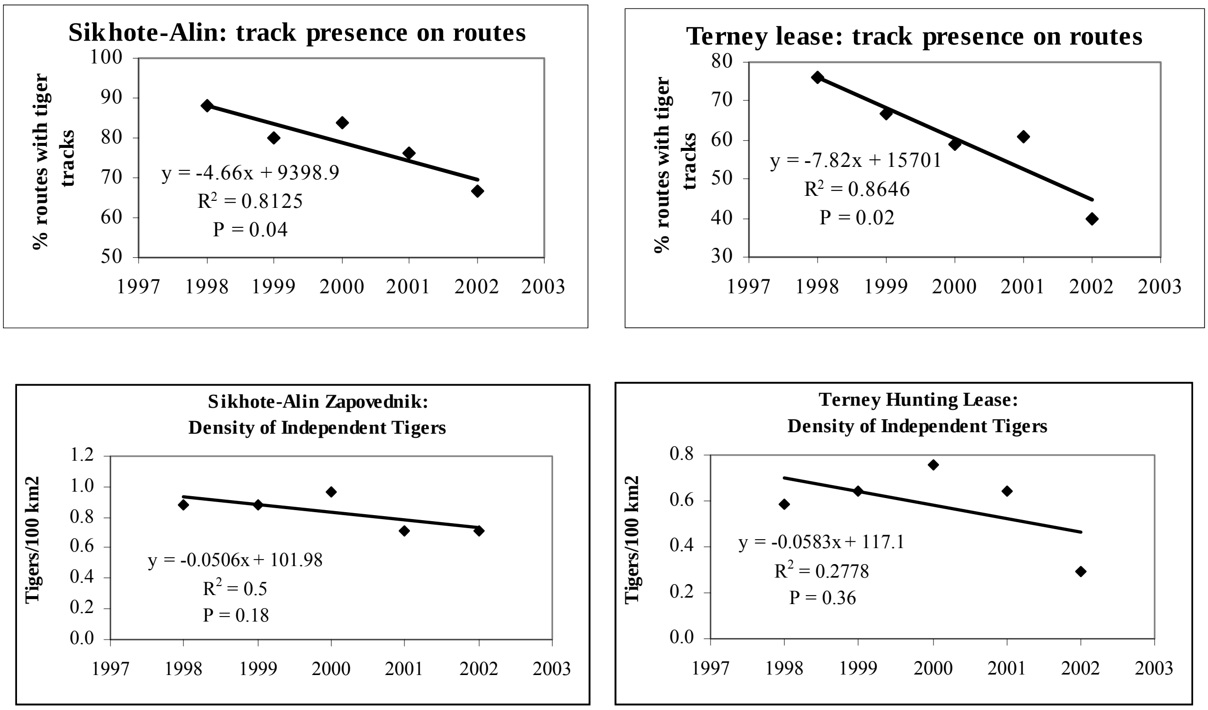


Figure 12c. Trend analyses for mean density of tiger tracks found in monitoring units for the past 4 years. Results are averaged for each year from 16 monitoring sites across tiger range in the Russian Far East, 1997-1998 through the 2001-2002 seasons.

Of particular concern are indicators from two monitoring sites in Terneiski Raion, Terney Hunting Lease and Sikhote-Alin Zapovednik, both of which have indicators strongly suggesting a decrease in tiger numbers (Figures 3 and 7). These decreases need timely responses to reverse downward trends in this region of Primorski Krai.

Also of concern is what appears to be a reduction in cub production (measured as both number of litters and number of cubs produced) in Khabarovski Krai (Figure 11). Although neither trend is significant and the absolute differences are relatively small, the decline in cub production is nearly statistically significant (P = 0.08). This trend deserves close monitoring next year, to determine if the trend continues.



Figures 3 and 7 from text. Indicators of tiger abundance (% of routes on which tiger tracks are found, and expert assessment of tiger numbers) on Terney Hunting lease and Sikhote-Alin Zapovednik. Trends from the 1997-1998 through 2001-2002 winter.

Overall, results provide an indicator that tiger numbers may be decreasing across the range of tigers, with the first noticeable signs coming from reductions in tiger numbers in northeast Primorye, and a reduction in reproductive output from Khabarovski Krai. Most of these indicators are as yet not statistically significant, and therefore we require at least one more year of monitoring before concluding that changes have occurred. However, the available information should act as an early warning signal that the status of the Amur tiger may be worsening.

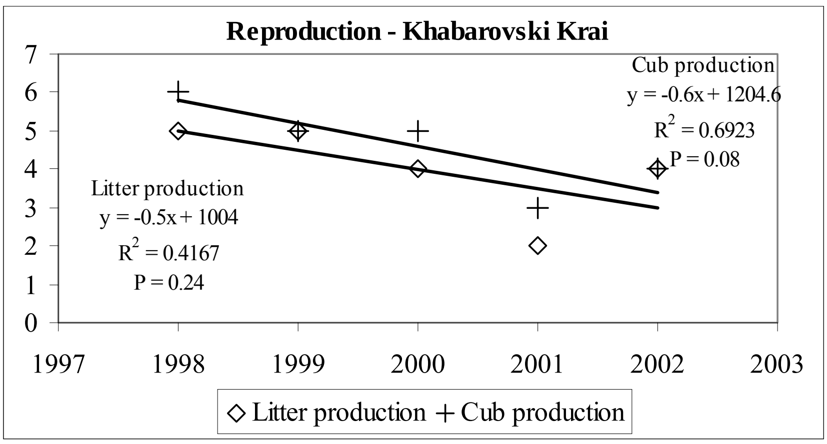


Figure 11. Litter and cub production on the 5 sites in Khabarovski Krai, 1997-1998 through 2001-2002, for the Amur Tiger Monitoring Program.

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 unmeasureable 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

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).

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

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).

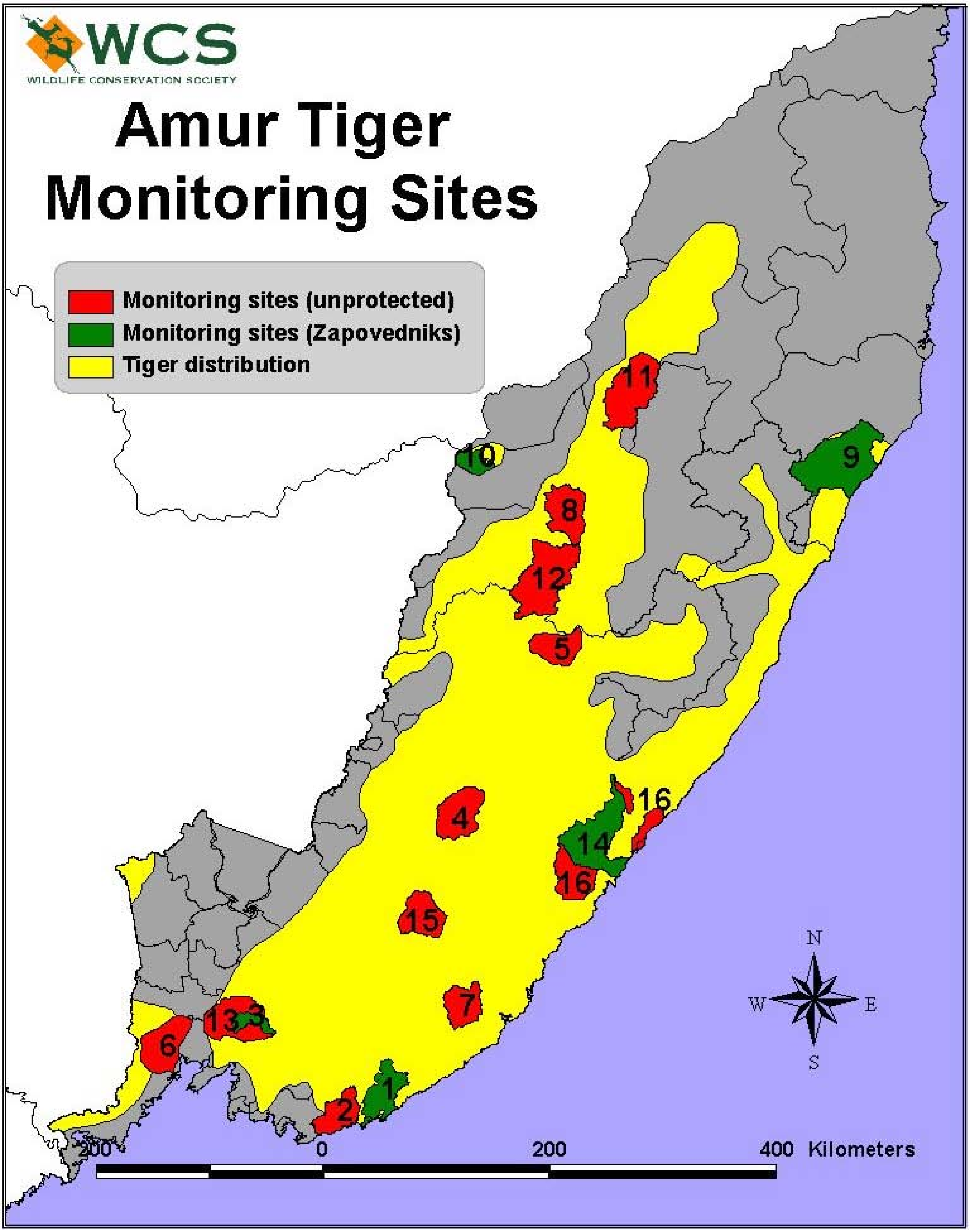


Figure 1. Location of the 16 sites used for monitoring Amur tigers in the Russian Far East. Numbers referenced in Table 1 and most other tables throughout text.

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 to1999 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	Track index		
(km)	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).

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
$\geq$13	90	0.411

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 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
-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" pairwise 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.

	Route length				
Trend	**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.

	Number of Routes .			
Trend	**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.

	.Alpha (α).			
Trend	**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 have 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 for the past 5 years 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.

IV. Literature Cited

Abramov, K. G. 1961. On the procedure for tiger census. Voprosy organizatsii i metody ucheta resursov fauny nazemnykn pozvonochnykh. Pages 53-54 *in* Mosk. Obschestvo Ispytaltely Prirody. Moscow, Russia. (in Russian).

Becker, E. F. 1991. A terrestrial furbearer estimator based on probability sampling. Journal Wildlife Management 55:730-737.

Beier, P. and S. C. Cunningham. 1996. Power of track surveys to detect changes in cougar populations. Wildlife Society Bulletin 24:540-546.

Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York, New York, USA.

Gibbs, J. P. 1995. Monitor user manual. Exter Software, Setauket, New York, USA.

Gerrodette, T. 1987. Power analysis for detecting trends. Ecology 68:1364-1372.

Hornocker Wildlife Institute. 1998. Monitoring the status of the Amur tiger population in the Russian Far East: a final report to the World Wildlife Fund-US and interim report to World Wildlife Fund-Germany.

Kaplanov, L. G. 1948. The tiger in Sikhote-Alin. Pages 18-49 *in* Tiger. Iziubr. Los." Materialy k poznaniyu fauny i flory SSSR. Izd. Mosk. Obschestva Ispytateley Prirody. Novaya seria. Otdel. zool. No. 14 (29). Moscow, Russia. (in Russian).

Karanth, K. U. 1995. Estimating tiger *Panthera tigris* populations from camera-trap data using capture-recapture models. Biological Conservation 71:333-338.

Karanth, K. U. and J. D. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79:2852-2862.

Kendall, K., L. H. Metzgar, D. A. Patterson, and B. M. Steele. 1992. Power of sign surveys to monitor population trends. Ecological Applications 2:422-430.

Matyushkin, E. N., D. G. Pikunov, Y. M. Dunishenko, D. G. Miquelle, I. G. Nikolaev, E. N. Smirnov, G. P. Salkina, V. K. Abramov, V. I. Bazylnikov, V. G. Yudin, and V. G. Korkishdo. 1996. Numbers, distribution and habitat status of the Amur tiger in the Russian Far East. Final report to the USAID Russian Far East Environmental Policy and Technology Project.

Manly, B. F. J. 1997. Randomization, bootstrap and Monte Carlo methods in biology. Chapman and Hall, London, United Kingdom.

Mescheryakov, V. S. and S. P. Kucherenko. 1990. Number of tigers and ungulates in Primorsky Krai: recommendations for protection and rational use. Final report. All Soviet Scientific Research Institute of Hunting Management, Far East Division of Primorye Commercial Hunting, and Primorsky Cooperative for Commercial Hunting. Vladivostok, Russia. (In Russian)

Matyushkin, E. N., and V. I. Zhivotchenko. 1979. Procedures of tiger counting in the zapovedniks of the Primorie. Pp. 250-251 in Ecologicheskie osnovy okhrany i ratsionalnogo ispolzovani khischnykh mlekopitaiuschikh. Materialy Vsesoiuzn. soveschania. Nauka, Moscow, Russia. (in Russian).

Morin, P. A. and D. S. Woodruff. 1996. Noninvasive genotyping for vertebrate conservation. Pages 298-313 *in* T. B. Smith and R. K. Wayne, editors. Molecular genetic approaches in conservation. Oxford Press, New York, New York, USA.

Pikunov, D. G. and A. P. Bragin. 1987. Organization and procedures for counting the Amur tiger. Pp. 39-42 in Organizatisia i metodika ucheta promyslovykh i redhikh mlekopitaiuschikh i ptits Dalnego Vostok. Tikhookeanskii institut geografii RAN. Preprint. Vladivostok, Russia. (in Russian).

Pikunov, D. G. 1990. Numbers of the Amur tiger in the Soviet Far East. Fifth Meeting of the All-Soviet Theriological Society 2:102-103. (in Russian)

Smirnov, E. N. and D. G. Miquelle. 1999. Population dynamics of the Amur tiger in Sikhote-Alin State Biosphere Reserve. Pages 61-70 *in* J. Seidensticker, S. Christie, and P. Jackson, editors. Riding the tiger; meeting the needs of people and wildlife in Asia. Cambridge University Press, Cambridge, United Kingdom.

Strayer, D. L. 1999. Statistical power of presence-absence data to detect population declines. Conservation Biology 13:1034-1038.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, California, USA.

Van Sickle, W. D., and F. G. Lindzey. 1991. Evaluation of a cougar population estimator based on probability sampling. Journal Wildlife Management 55:738-743.

Yudakov, A. G., and I. G. Nikolaev. 1973. Status of the population of the Amur tiger in Primorskiy Krai. Zoologicheskii Zhurnal 52:909-919. (In Russian).

Yudakov, A. G., and I. G. Nikolaev. 1979. The distance covered by the Amur tiger in a 24-hour period. Byulleten' Moskovskogo Obshchestva Ispytateley Prirody. Otdel Biologicheskiy. 84:13-19. (In Russian).

IV. RESULTS OF THE 2001-2002 WINTER MONITORING PROGRAM

Summary Data on Count Units and Routes

As in previous years, in the 2001-2002 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 3).

Table 1. Characteristics of units surveyed for Amur tiger monitoring program, 2001-2002.

	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	12.42805	1.30

Snow depth was greater than normal in 10 of the 16 monitoring sites (Figure 1). Unsually deep snows were especially common in the coastal regions (e.g. Borisovkoe Plateau, Botchinskii Zapovednik, Terney hunting lease, Sikhote-Alin Zapovednik and Lazovskii region). These unsually deep snows may have had serious impacts on ungulate populations overwintering in these areas (see individual reports, Part II), and may affect reduce activity and distance traveled by animals (both tigers and their prey), thus reducing track counts.

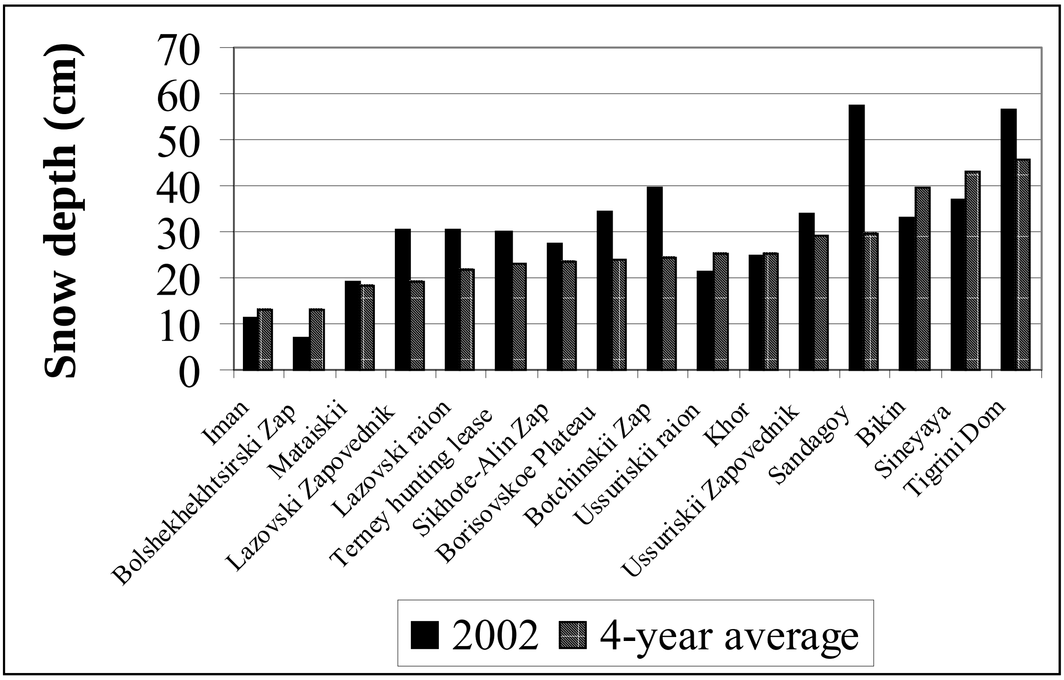


Figure 1. Snow depth on routes within monitoring sites of the Amur Tiger Monitoring Program, for February, 2001-2002 compared to 4-year average (1999-2002: data from 1998 not available).

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 2001-2002 winter 38% of routes on monitoring sites did not intersect tiger tracks, the highest average in the 5 years of monitoring (Table 2). There is a non-significant downward trend in the number of routes with tracks recorded (Figure 2). Lack of significance is largely due to the high average estimate for the 2000 winter (Figure 2). Despite the low correlation value ($r^2 = 0.31$), the trend is noteworthy.

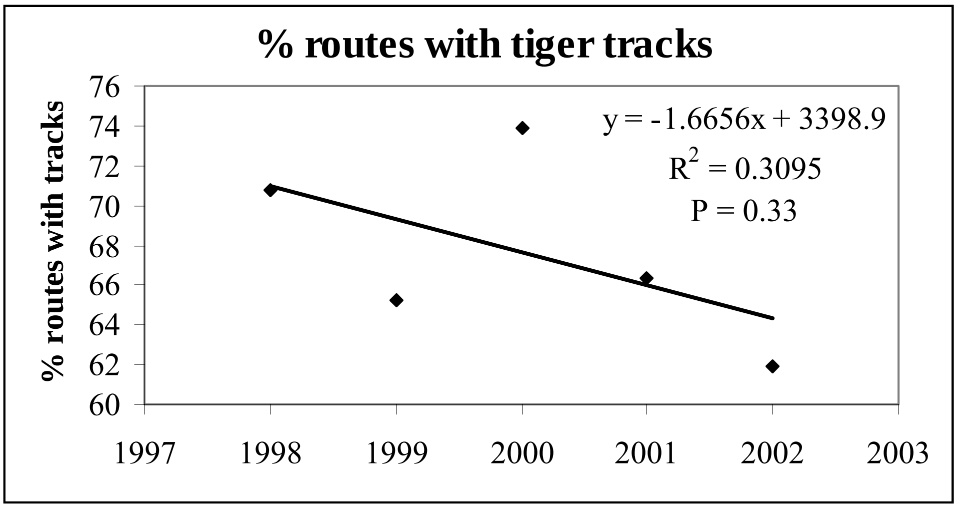


Figure 2. Overall trends in presence of tiger tracks on routes, averaged for all 16 sites of the Amur Tiger Monitoring Program, from the 1997-1998 winter through 2001-2002 winter season.

Table 2. Percentage of routes with tiger tracks present on 16 sites during the first five years of the Amur Tiger Monitoring Program.

Monitoring unit	**1997-1998**	**1998-1999**	**1999-2000**	**2000-2001**	**2001-2002**	**Average (1998-2002)**
Lazovski Zapovednik	91.7	83.3	100	100	100	95
Lazovski raion	100	72.7	63.6	45.5	90.9	74.5
Ussuriskii Zapovednik	90.9	100	90.9	90.9	81.8	90.9
Bikin	63.6	87.5	87.5	93.7	81.2	82.7
Iman	91.7	66.7	75	91.7	75	80
Mataiskii	68.4	79.2	50	58.3	75	66.2
Khor	62.5	31.6	89.5	57.9	68.4	62
Sikhote-Alin Zapovednik	88	80	84	76	66.7	78.9
Botchinski Zap	64.3	57.1	85.7	100	64.3	74.3
Tigrini Dom	50	64.3	71.4	78.6	64.3	65.7
Ussuriskii raion	66.7	33.3	100	33.3	58.3	58.3
Borisovkoe Plateau	57.1	57.1	50	57.1	50	54.3
Terney hunting lease	76.2	66.7	59.1	60.9	40	60.6
Bolshekhekhtsirski Zapovednik	57.1	42.9	85.7	14.3	28.6	62.9
Sineyaya	50	53.3	46.7	46.7	26.7	44.7
Sandagoy	53.3	68.7	43.7	56.2	18.7	48.2
Average % routes without tracks	70.719	65.275	73.925	66.319	61.869	68.7

Percentage of routes without tiger tracks varied from 0 to 81% among monitoring units in the 2001-2002 winter (Table 2). In general, presence/absence indices for 2001-2002 followed patterns of previous years for specific monitoring units (Table 2), but there were some important changes (Figure 3). Five monitoring sites have demonstrated trends in percentage of routes with tiger tracks across the 5 years of monitoring, and all of them have been downward trends (Figure 3a-e). Terney Hunting lease has demonstrating regular declines over the past 5 years, in concert with the apparent declining trend in the adjacent Sikhote-Alin Zapovednik. The fact that these two sites lying adjacent to each other demonstrate statistically significant downward similar trends is noteworthy. The other three sites, Lazovski Raion, Sineyaya, and Sandagoy, show trends that are not statistically significant (below our cut-off value of P = 0.2), and are worth considering in light of other indicators of tiger status on those sites

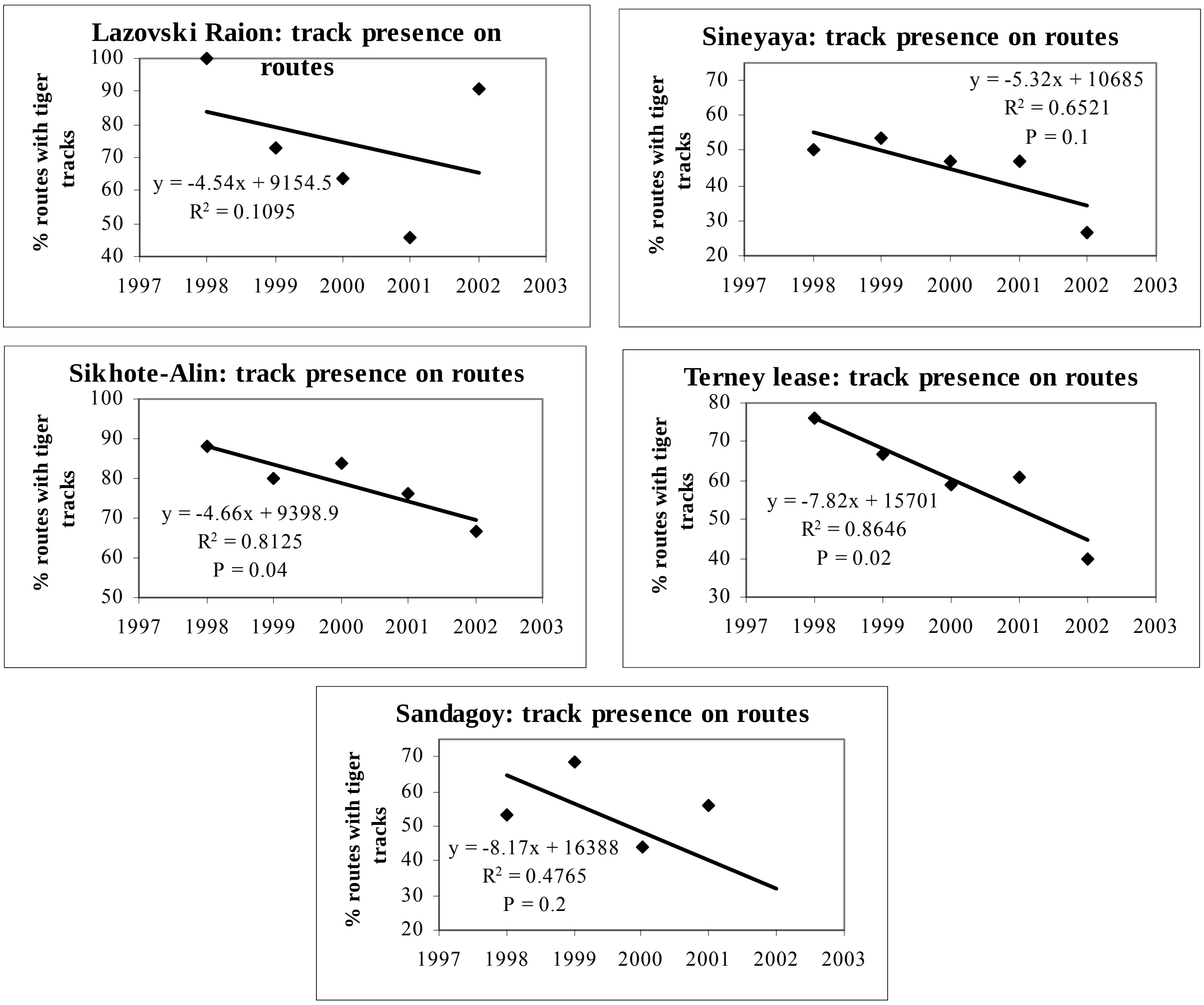


Figure 3a. Monitoring units which have shown a drop ($P < 0.2$ for the regression) in percentage of survey routes with tiger tracks found across all 5 years of the Amur Tiger Monitoring Program, 1997-1998 through 2001-2002 winter seasons. Statistically significant drops occurred in Sikhote-Alin Zapovednik and Terney Hunting lease.

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. Ussuriski and Lazovski Zapovedniks ranked highest in track densities for 2002, but density of tracks in Sikhote-Alin Zapovednik fell from previous years (Table 3). Track density in the Bikin monitoring site was high (Table 3) as were estimates for two units in Khabarovsk (Khor, and Tigrini Dom). Track density in Tigrini Dom has increased rather consistently over all 5 years of monitoring (Table 5).

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

Monitoring unit	1998	1999	2000	2001	2002	Unit mean
Ussurisk Zapovednik	3.28	9.66	6.45	6.15	3.49	5.81
Lazovski Zapovednik	3.62	2.19	3.08	3.57	2.52	3.00
Bikin	3.61	7.71	0.95	3.70	2.31	3.66
Ussuriski Raion	1.01	0.61	1.93	1.44	1.70	1.34
Tigrini Dom	0.67	1.47	1.13	1.51	1.66	1.29
Lazovski Raion	1.44	0.67	0.99	1.02	1.62	1.15
Khor	0.44	0.80	1.67	1.50	1.35	1.15
Botchinski Zapovednik	0.88	0.74	1.20	1.29	1.04	1.03
Sikhote Alin Zapovednik	1.99	1.28	1.52	1.18	0.91	1.37
Iman	0.96	2.81	0.86	0.76	0.81	1.24
Bolshekhekhtsirki Zapovednik	1.51	1.47	0.84	0.71	0.71	1.05
Borisovskoe Plateau	0.50	0.85	1.45	0.60	0.51	0.78
Terney Hunting Lease	0.83	0.64	0.73	0.90	0.39	0.70
Sineya	0.24	0.33	0.47	0.58	0.38	0.40
Mataiski Zakaznik	0.63	1.18	0.73	2.42	0.38	1.07
Sandagoy	0.47	0.66	0.34	0.41	0.23	0.42
Yearly mean	3.62	9.66	6.45	6.15	3.49	5.87

As with presence/absence data, we looked for trends in the tiger population using track data by applying a regression analysis to all 16 monitoring sites combined (Figure 4), and to individual sites (Part II). When looking at the overall regression for 5 years combined, no significant trend in track density was noted ($r^2 = 0.056$, $F = 0.18$, $P = 0.7$) (Figure 4a). However, if we focus on only the past four years (deleting 1998 from the analysis) there is in fact a significant downward trend overall ($r^2 = 0.92$, $F = 24.16$, $P = 0.04$) (Figure 4b). Five individual sites showed trends for which their P value (for the test that the slope of the line did not equal zero) was less than 0.20 (Figure 5). Three these showed negative trends in track densities (Sandagoy, BolsheKhekhtsirski, and Sikhote-Alin Zapovednik), while two (Khor and Tigrini Dom), demonstrated significant positive trends (Figure 5). Terney Hunting Society, adjacent to Sikhote-Alin Zapovednik, showed a marginal non-significant trend ($P = 0.22$), supporting the conclusion that tiger track densities in this region were low for the 2002 winter.

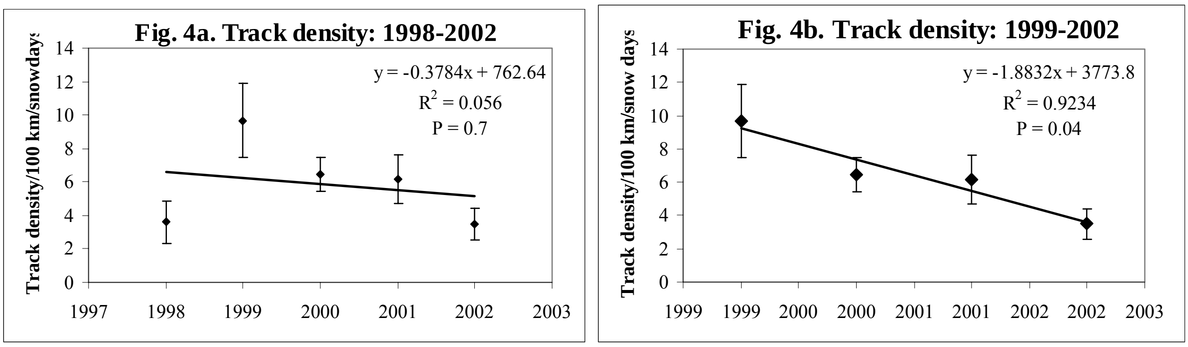
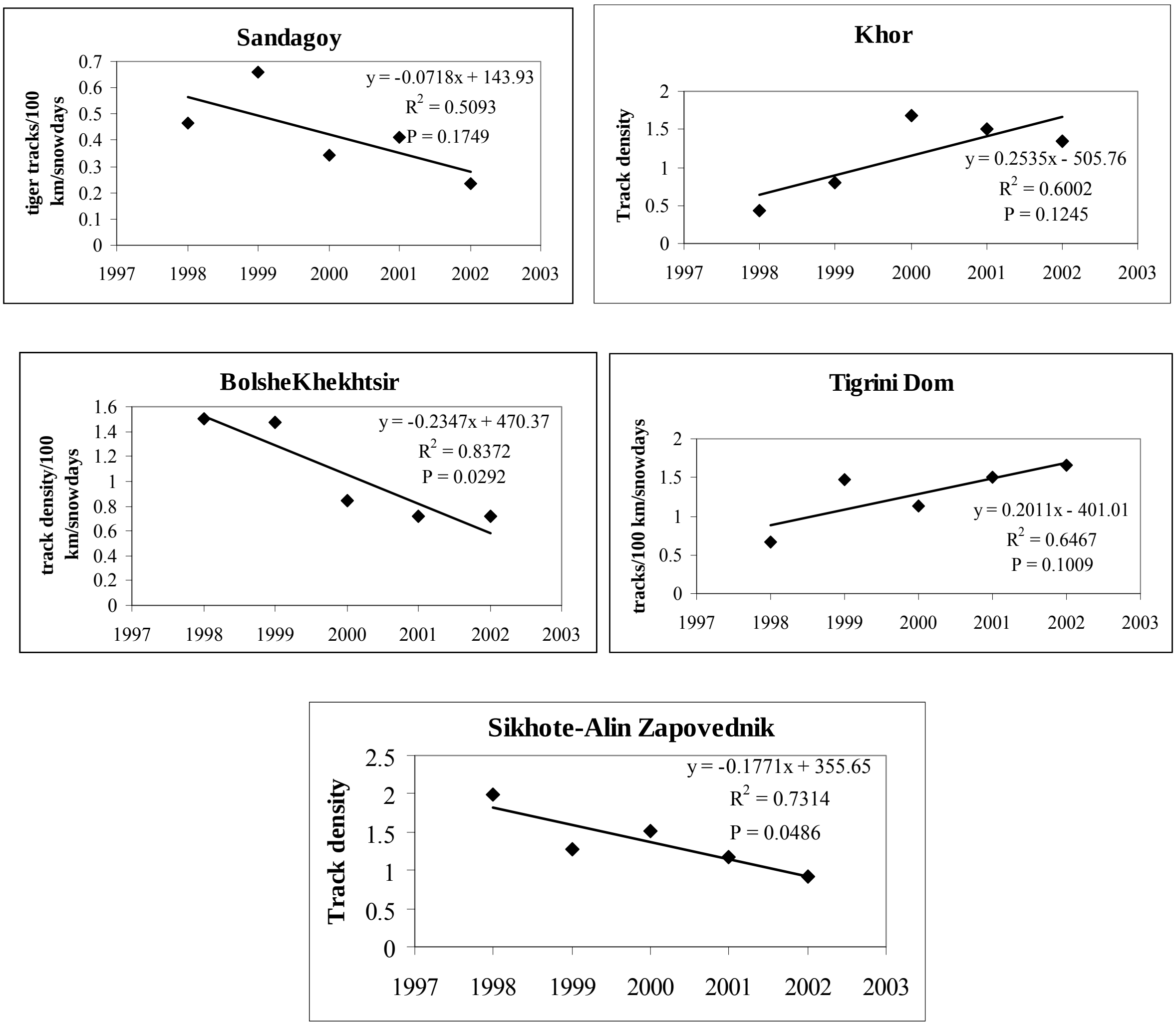


Figure 4. Density of tiger tracks (tracks/100 km/days since last snow) as indicators of tiger abundance on 16 sites included in the Amur Tiger Monitoring Program, a: 1997-1998 through 2001-2002 winters; b: 1998-1999 through 2001-2002 winters.



Figures 5a-e. Trends in track density estimators (calculated as the number of tiger tracks/days since last snow x100 km of transects covered) for 5 years on 5 sites for which P-values of the regression analysis (test that B, or slope of the line, does not equal 0) were less than 0.20: a) Sandagoy, b) Khor, c) Bolshe- Khekhtsirski Zapovednik, d) Tigrini Dom, and e) Sikhote-Alin Zapovednik).

Expert Assessment of Tiger Numbers on Monitoring Sites

Tiger densities, based on expert assessments, varied nearly fivefold, from over 1 animal/100 km^2 in Ussuriski Zapovednik, to 0.2 /100 km^2 in Botchinski Zapovednik and Matai Zakaznik (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 0.7/100 km^2), indicating once again that protected status is an important parameter determining tiger density (Table 4).

As with presence/absence and track density data, we conducted a trend analysis with expert estimates of tiger density. Although there is a downward tendency in tiger density estimates, there was no significant trend ($r^2 = 0.32$, $P = 0.32$) (Figure 6).

Although expert assessments of tiger densities appeared to be stable overall, two sites showed significant increases in tiger numbers over the past five years. Both Lazovski and Botchinski Zapovedniks have demonstrated a consistent upward trend in the number of independent tigers reported by expert assessments in these two protected areas (Figures 7a-b). At the same time, Terney Hunting Lease and Sikhote-Alin Zapovednik showed downward trends (Figures 7c-d). Although the P value for Terney Hunting Lease is above our cut-off value of 0.2, we have included it here because it reflects the same pattern as depicted in the presence/absence and track density parameters. Northeast Primorski Krai appears to be suffering a decline in tiger numbers.

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 five years of monitoring, 1997-1998 through 2001-2002.

	Number of independent tigers					Density independent tigers/100 km^2					
Monitoring site	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	5-year average
Lazovski reserve	6	9	10	11	12	0.50	0.75	0.84	0.92	1.01	0.81
Ussurisk Zapovednik	6	10	4	5	4	1.47	2.45	0.98	1.22	0.98	1.42
Sikhote Alin Zapovednik	21	21	23	17	17	0.88	0.88	0.97	0.72	0.72	0.83
Bikin	3	10	7	6	7	0.29	0.97	0.68	0.58	0.68	0.64
Ussuriski Raion	6	1	2	2	9	0.42	0.07	0.14	0.14	0.64	0.28
Lazovski Raion	8	4	5	4	6	0.81	0.41	0.51	0.41	0.61	0.55
Iman	8	6	5	6	6	0.57	0.43	0.36	0.43	0.43	0.44
Sineya	5	6	5	7	5	0.43	0.51	0.43	0.60	0.43	0.48
Sandagoy	6	6	5	7	3	0.61	0.61	0.51	0.72	0.31	0.55
Khor	3	4	4	4	4	0.22	0.30	0.30	0.30	0.30	0.28
Terney Hunting Lease	10	11	13	11	5	0.58	0.64	0.76	0.64	0.29	0.58
Tigrini Dom	4	6	4	4	5	0.19	0.29	0.19	0.19	0.24	0.22
Khekhtsirki Zapovednik	2	1	2	1	1	0.42	0.21	0.42	0.21	0.21	0.29
Borisovskoe Plateau	4	5	4	3	3	0.27	0.34	0.27	0.20	0.20	0.26
Mataiski Zakaznik	3	5	4	4	5	0.12	0.20	0.16	0.16	0.20	0.17
Botchinski Zapovednik	3	3	4	4	6	0.10	0.10	0.13	0.13	0.20	0.13
Total/average	98	108	101	96	98 /	0.49	0.57	0.48	0.47	0.46	0.50

The value of zapovedniks as refuges for tigers was reconfirmed with data from this past season (Figure 8). As in all past years, tiger density, as estimated by local experts, was significantly greater inside zapovedniks than in other monitoring sites. This difference was magnified this year by a substantial jump in estimates of the number of tigers in Lazovski

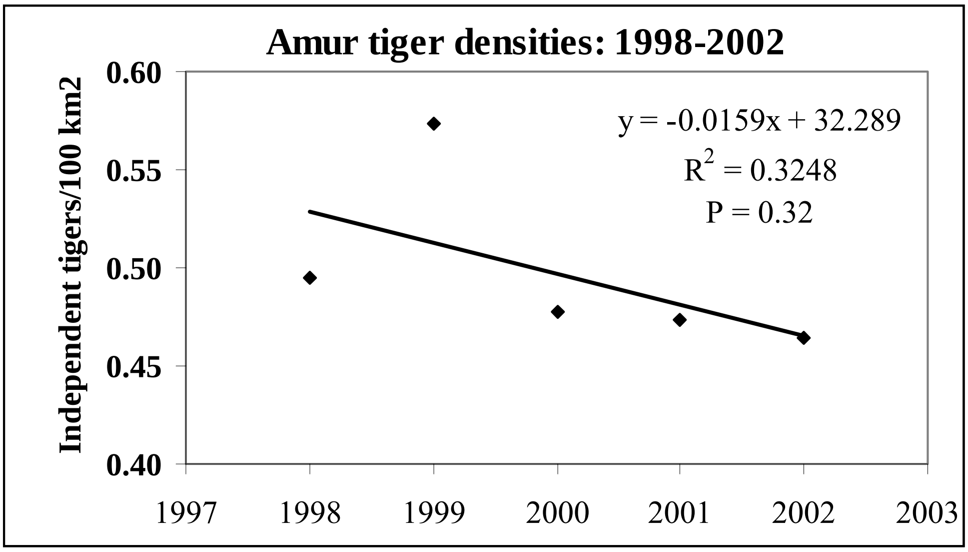


Figure 6. Trend in density of independent tigers (/100 km^2), based on expert assessments, for 16 sites in the Amur Tiger Monitoring Program, 1997-1998 through 2001-2002 winter seasons.

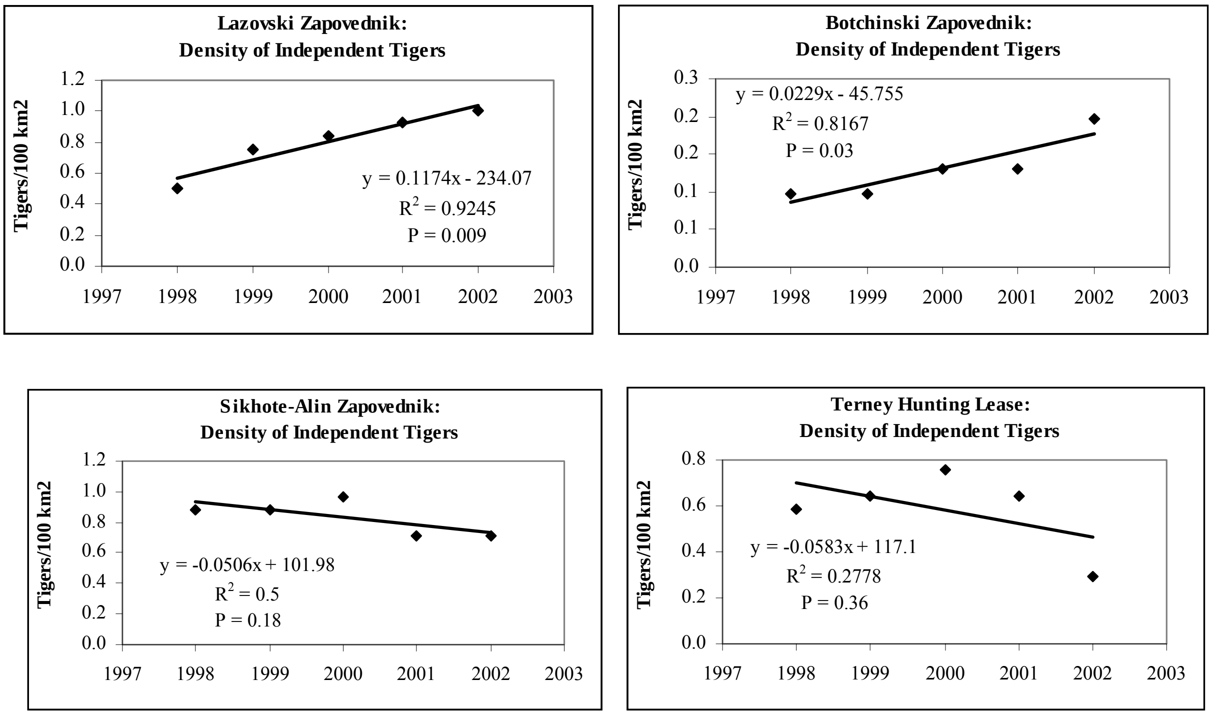


Figure 7. Regression analyses for individual monitoring sites with P-values of a linear regression < 0.20 for changes in density of independent tigers across the five years of the monitoring program, winters 1997-1998 through 2001-2002.

Zapovednik. High variability in tiger density amongst zapovedniks is due to low densities in the two northernmost zapovedniks – Bolsekhekhtzirski and Botchinski – the former is a small isolated fragment that varies greatly in tiger density due to localized extinction and recolonization phases, and the second occurs along the northernmost edge of tiger habitat along the coast. The other three zapovedniks, occurring in the core of the range, represent the best available habitat for tigers, predominantly due to their protected status.

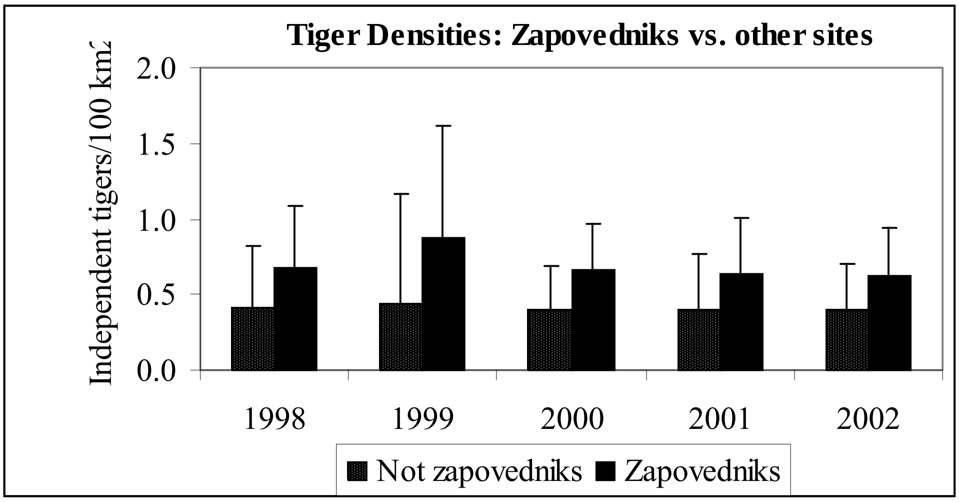


Figure 8. Density of independent tigers (/100 km^2) in protected (zapovedniks) versus unprotected areas included in the Amur tiger monitoring program 1997-1998 through 2000-2001.

Reproduction on Monitoring Sites

Expert assessments of tiger numbers and sex-age structure provide an opportunity to track changes in reproduction over time. 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.

Table 5. Number of litters, and number of cubs produced on each monitoring unit for 5 winters, 1997-1998 through 2001-2002, 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	Total litter production	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	Total litter production
Lazovski Zapovednik	1	1		2	2	6	2	2		5	4	13
Lazovski Raion	3	2		1	4	10	3	3		3	7	16
Ussurisk Zapovednik	3	4	1	1	2	11	4	4	3	2	4	17
Iman		2	1	1	1	5		3	2	2	1	8
Bikin	3		1		1	5	3		1		2	6
Borisovskoe Plateau	2	1	1	1		5	2	1	1	1		5
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	7	4	2	2		1	9
Ussuriski Raion		1				1		2				2
Sikhote Alin Zapovednik	4	3	2	2		11	4	4	2	3		13
Sineya	1				1	2	1				3	4
Terney Hunting Lease	1	2	1	1	1	6	1	2	1	1	1	6
Total	26	22	11	11	17	87	30	27	15	20	28	120

Since the 1997-1998 winter the number of litters reported on all sites combined has ranged from 11 to 26, with 17 litters reported for the 2001-2002 winter (Table 5, Figure 9). During the same time, the total number of cubs has ranged from 15 to 30. Although number of litters was approximately the 5-average (17.4), number of cubs produced (28) was near the maximum reported (30). The percentage of units with cubs reported has ranged from 62 to 75% of all 16 monitoring sites (Table 5, Figure 9), with this year (67%) very close to the 5-year average (69%). 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 (Table 5), but only two sites, Ussuriski Zapovednik and Terney Hunting lease, has reported reproduction in each of those 5 years. In Terney Hunting lease, one radio-collared tigress ("Olga) has been a stable presence on the unit during the entire monitoring program, and is responsible for a large percentage of the reproductive activity on that site.

Although litter production has been lower in the past three years than the first two, the number of cubs produced has rebounded to higher levels (Figure 9), due to larger litter sizes over the past two years (Table 6).

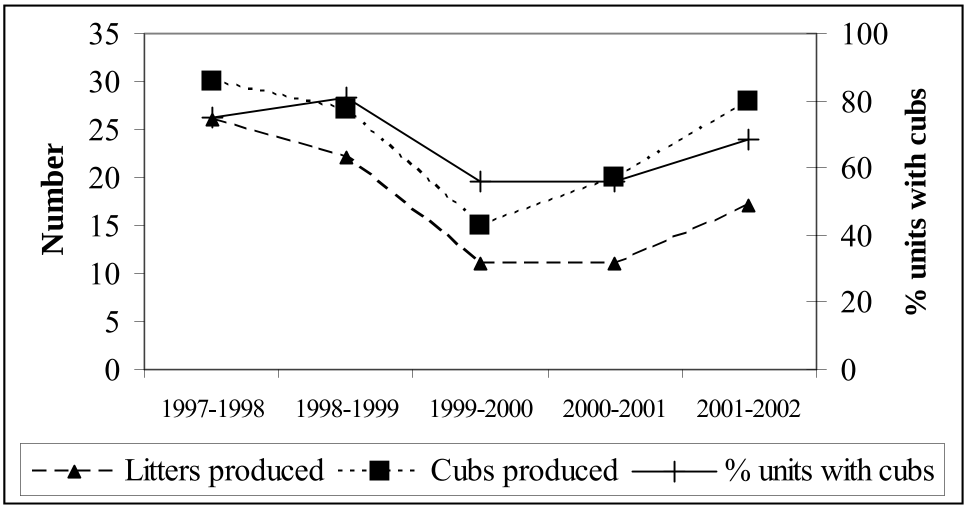


Figure 9. Cub and litter production, as well as percent of monitoring units with cub production, for the 5 winter seasons, 1997-1998 through 2001-2002, for the Amur Tiger Monitoring Program.

Table 6. Litter size of all litters recorded in 5 winters of the Amur Tiger Monitorir Program, 1997-1998 through 2001-2002, based on expert assessment of tracks.

	Litter size			Total #	Total #
Year	1	2	3	litters	cubs
1997-1998	22	4	0	26	30
1998-1999	17	5	0	22	27
1999-2000	8	2	1	11	15
2000-2001	4	5	2	11	20
2001-2002	8	7	2	17	28
Total	59	23	5	87	120

All other indicators (presence/absence, track density, and tiger density) suggest that tiger densities are higher in zapovedniks, and we would therefore expect that conditions are better there (e.g. prey densities higher) and therefore productivity should be higher as well. In fact, in four of five years cub density was higher in zapovedniks than in other monitoring units, but in the last season (2001-2002) cub density was approximately equivalent averaged across both types of units (Figure 10). The lowered productivity in zapovedniks this past season was due to a lack of cubs in 3 of the five zapovedniks (Table 5). Although overall cub density is greater than two times higher in zapovedniks (0.19 versus 0.08, averaged across all years), there so much variation among and between sites that an ANOVA failed to detect a difference between zapovedniks and other sites, using means for each site across all 5 years ($F = 2.05$, $df = 1, 14$, $P = 0.17$). Despite the absence of statistical significance, the results generally indicate that zapovedniks are responsible for a disproportional share of cub production: while zapovedniks have produced 43% of cubs on monitoring sites over the 5 years of the program, they represent only 32% of the land monitored.

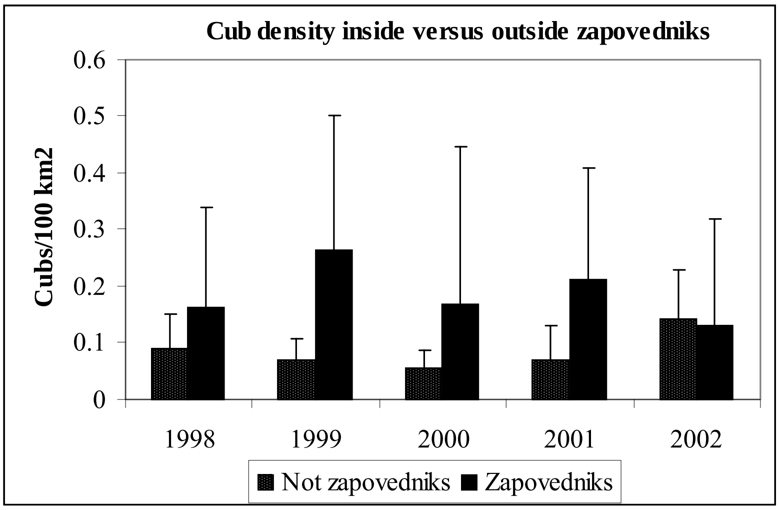


Figure 10. Cub density inside zapovedniks versus other monitoring sites during the first 5 years of monitoring Amur tigers in the Russian Far East.

Local differences in reproduction do exist across tiger range in the Russian Far East. Yu. Dunishenko, coordinator for tiger monitoring in Khabarovski Krai, the northernmost range of tigers, reports that cubs represent a decreasing percentage of the population, suggesting a decrease in recruitment. (see Part II). Looking at both litter and cub production, there does appear to be a reason for concern (Figure 11). Although neither trend is significant and the absolute differences are relatively small (Table 5), the decline in cub production is nearly statistically significant ($P = 0.08$). This trend deserves close monitoring next year, to determine if the trend continues.

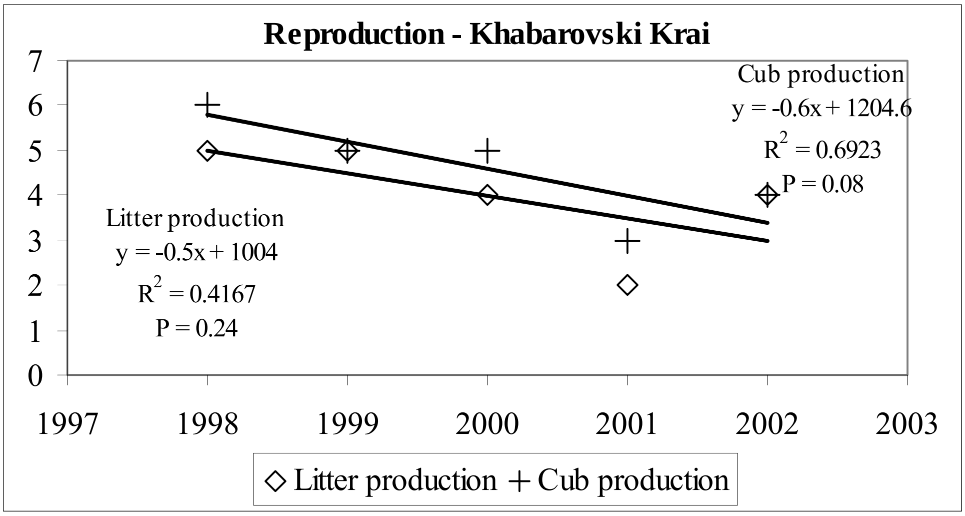


Figure 11. Litter and cub production on the 5 sites in Khabarovski Krai, 1997-1998 through 2001-2002, for the Amur Tiger Monitoring Program.

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. 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.

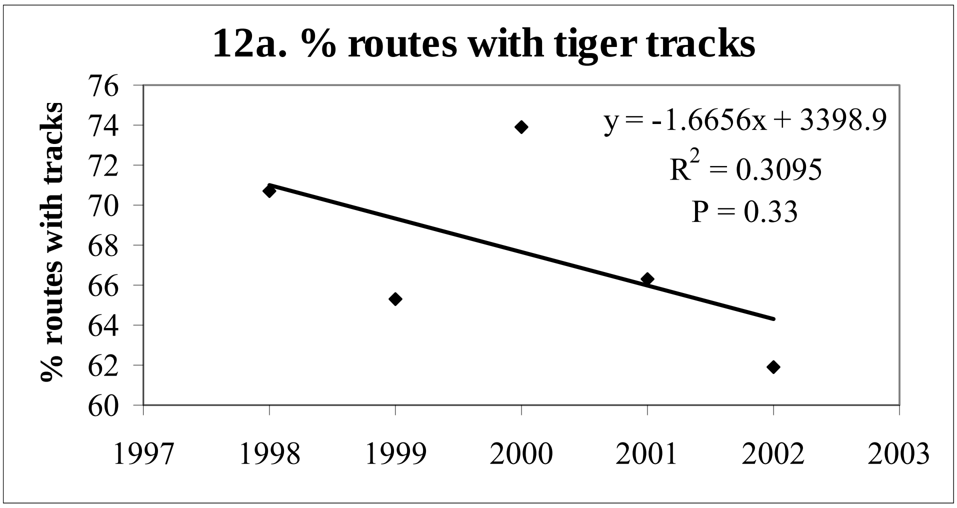
To balance this conservative approach, we have used three indicators of tiger abundance that could signal changes in the population. We consider changes to be important if two of the three indicators indicate a similar pattern.

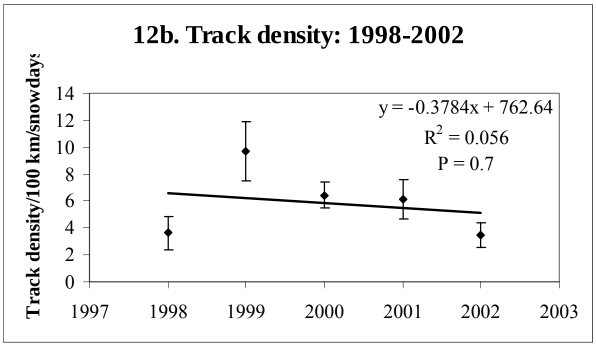
Using the criteria defined above, we would interpret that, overall the population of Amur tigers, based on average estimates derived from the 16 monitoring sites, appears to be relatively stable. However, for the first time in the 5 years of monitoring the Amur tiger population, all three indicators suggest a negative trend (Figure 12a-d). If we consider track densities over the past 4 years (ignoring the first year), that trend is highly significant. Thus, despite the fact that none of the indicators are significant (using all 5 years), we believe the data indicates that the Amur tiger population in the Russian Far East may be falling.

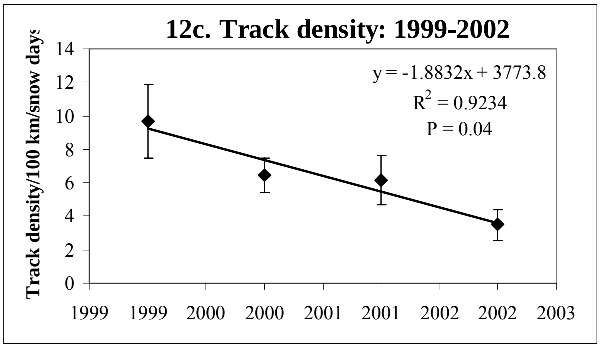
Whereas last year seven sites had at least one indicator of tiger abundance suggesting positive growth was occurring ($P < 0.2$ for the trend analysis), this year there were only four such sites, and no site had two indicators in this range, the first time this has occurred in the five years of monitoring (Table 7). Whereas last year only two sites had indicators suggesting declines in tiger numbers, this year there are five sites that have at least one trend indicator within the range suggesting potential decline (i.e., $P < 0.2$ for a negative slope). Two of these sites had one indicator suggesting a negative trend (Sineyaya and BolsheKhekhetirski), two other sites had two indicators suggesting a decrease in tigers (Sandagoy and Terney Hunting Lease), and in Sikhote-Alin Zapovednik all three indicators suggested a decline in tiger numbers.

Last year we believed Lazovski Raion was an area of concern. This year tiger numbers, based on expert assessments, appeared to increase in this area, and numbers in Lazovski Zapovednik appear stable.

Along with measures of tiger abundance, reproduction is a second important indicator of population status. Eleven of the 16 monitoring sites reported cubs from the past winter season (Table 7), two more than last year. Including solo cubs without mothers, numbers of cubs appears to have risen, averaged across all sites. But reproduction appears to have been







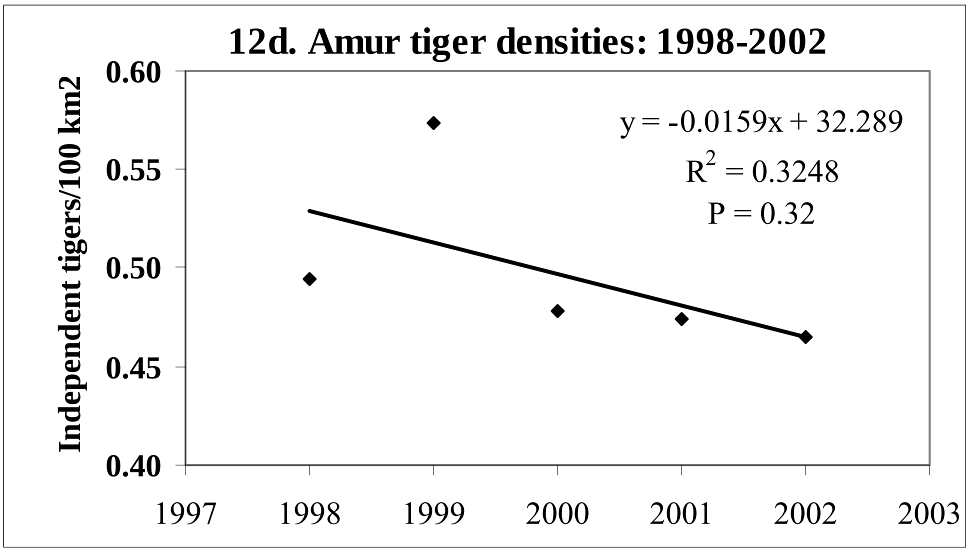


Figure 12a-d. Trend analyses for three indicators of tiger abundance: a) % routes with tiger tracks present; b) mean track density for all 5 years; c) mean track density for past 4 years; d) density of independent tigers, based on expert assessment. Results are averaged for each year from 16 monitoring sites across tiger range in the Russian Far East, 1997-1998 through the 2001-2002 seasons.

concentrated in Primorye, while cub production in Khabarovsk appears to be decreasing (Figure 11).

Based on the results of this year's analysis in comparison to data from the past 4 years, we believe there are two primary areas of concern. First, it appears that tiger numbers are declining in Sikhote-Alin Zapovednik and surrounding territories of the Terney Hunting Lease. This may be indicative of a general decline across northeastern Primorye, and should be a focal point for conservation actions. Secondly, available evidence suggests that reproduction may be declining in Khabarovski Krai, which will ultimately result in a decrease in tiger numbers if this trend is not reversed. Finally, for the first time in our program, we have evidence that the Amur tiger population may be declining. While the trend indicators are not sufficiently strong to raise a strong alarm call, the data suggest that next year will be a critical year to assess whether the discerned trend continues, or changes. Based on results of next winter's data, there may be a need to be more active in conservation recommendations.

Table 7. Indicators of abundance and reproduction on 16 monitoring sites of the Amur Tiger Monitoring Program for the 2001-2002 winter season.

		Trend analyses			
		Tiger abundance			Reproduction
#	Name	% tiger presence on rtes	Tiger track density	Tiger density	Reproduction this year
8	Khor		+		+
2	Lazovski Raion			+	+
11	Tigrini Dom		+		+
5	Bikin River				+
1	Lazovski Zapovednik				+
12	Matai River Basin (Zakaznik)				+
3	Ussuriski Zapovednik				+
4	Vaksee (Iman)				+
9	Botchinski Zapovednik			+	-
15	Sineya (Chuguevski Raion)	-			+
6	Borisovkoe Plateau				-
7	Sandagoy (Olginski Raion)	-	-		+
16	Terney Hunting lease	-		-	+
13	Ussuriski Raion				-
10	Bolshe Khekhtsirski Zapovednik		-		-
14	Sikhote-Alin Zapovednik	-	-	-	-

"+" indicates $P < 0.2$ for trend analysis suggesting growth in numbers of tigers or evidence of reproduction.

"-" indicates $P < 0.2$ for trend analysis suggesting decline in numbers of tigers or no evidence of reproduction occurring on the monitoring unit.

V. LITERATURE CITED

Conover, W. J. 1980. Practical nonparmetric statistics, 2nd Edition. John Wiley & Sons.

Hayward, G. D., D. G. Miquelle, E. N. Smirnov, and C. Nations. In press. Monitoring Amur tiger populations: characteristics of track surveys in snow. J. Wildl. Manage.

Thompson, W. L., G. C. White, C. Gowan. 1998. Monitoring vertebrate populations. Academic Press.

SAS 1998. SAS Release 6.12 TS Level 025. SAS Institute Inc. Cary, N.C.

VI. REPORTS ON INDIVIDUAL MONITORING SITES 2000-2001

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 2001-2002
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 25-26 and February 15-16 (except survey route # 4, which was traveled on 27th of December and 17th of February)
4. *Routes ##*: 1-12
5. *Total length of routes*: All survey routes (total length is about 130 km) were traveled on foot.
6. *Survey conditions*: this winter the first snow fell on December 13. The survey was conducted 11-12 days after last snowfall. Snow depth in different sites varied from 8 to 20 cm. Valleys were completely covered with snow, but slopes were partly free of snow by the time of survey. Heavy snowfall took place on January 7-8, after that snow fell several times more but did not cover all the tracks that were left after January 8. Therefore, tracks left after this snowfall remained until survey in February that was conducted 38-39 days later. At that time snow depth varied from 18 cm on southern slopes on seashore to 55 cm in valleys inland. During survey in February there was thaw.

7. *Assessment of efficiency*: In December snow depth did not cause difficulties in survey conducting. Weather conditions were favorable for data collection. In February snow cover was deeper and it was impossible to travel along survey routes without broad skies. Snow was wet and adhered to skies. Due to this fact survey route # 7 was not covered completely (1 km less). During survey in February it was difficult to determine freshness/age of tracks and to make measurements, therefore sex and age of many tigers were not identified.

8. *Summarizing of 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. Reserve should provide suitable habitats for all these species and there all habitat types here for these animals - from oak forests to fir-spruce taiga. There was no rich harvest of acorns and pinecones in fall 2001. Wintering conditions for ungulates were moderate. First heavy snowfall took place in early January. There was wet snow on the seashore, tree branches and trunks broke under its weight, therefore many trees were broken. In Petrovskiy creek valley up to 10 broken tress could be counted from one site. Sika deer browsed broken and bent down tree branches. Probably this was the reason why only few sika deer moved to the road, where they are easy prey for poachers.

   In the second half of January southern slopes on the seashore were free of snow and it made difficult tracking of ungulates (tracking of daily movements of deer). In general winter was not severe and thaws often took place. There were no snowfalls in March.

   Icy crust over snow formed after thaws and it could easily bear the weight of dogs. This winter 7 dead sika deer were found and the reason of their death was not determined. These sika deer were well-fed and with no evidence of any injuries. Snow depth was not excessive (more than 40-50 cm) at the place where sika deer were found. In these areas feral dogs were registered (individuals and troops) and dead sika deer (4) were found. On 6th of January in tributary of Petrovskiy creek I observed a dog hunting for 2 deer. One dog can not kill adult deer but it is known that deer are afraid of dogs terrifically and lasting chasing can cause the death of deer. Probably this is the cause of many deer deaths but not snowfalls and lack of forage. In the reserve 26 sika deer, 1 roe deer and 1 red deer were poached. The number of poached animals decreased in comparison with previous year. On one hand, may be it is because the first snow fell only in the middle of December and heavy snowfall took place only in early January and ungulates did not move down to the valleys (where roads are), on the other hand the reason is low density of ungulates in areas where poaching often takes place.

In comparison with previous year densities of red deer and sika deer decreased, wild boar density slightly increased and roe deer density is on the same level.

Status of tiger population in comparison with previous information (for example with data of Tiger census 1996).

In comparison with survey results of previous year and Tiger Census in 1996 the number of tigers (excluding cubs) in model unit has slightly increased (by two individuals). Last year and this year the number of litters and cubs increased in comparison with previous years. One litter, which was registered on the coast last year, was found (with female) this season as well. Some cubs from another litter (in inland part of the reserve) are likely alive/survive. For the first time during many years litter was found in Preobrazhensky forest district (Sokolovka river basin and adjacent coastal area).

On the other hand frequency of tiger presence in the reserve is decreasing. For example during 40 days after snowfall tigers were found on routes only 2-3 times.

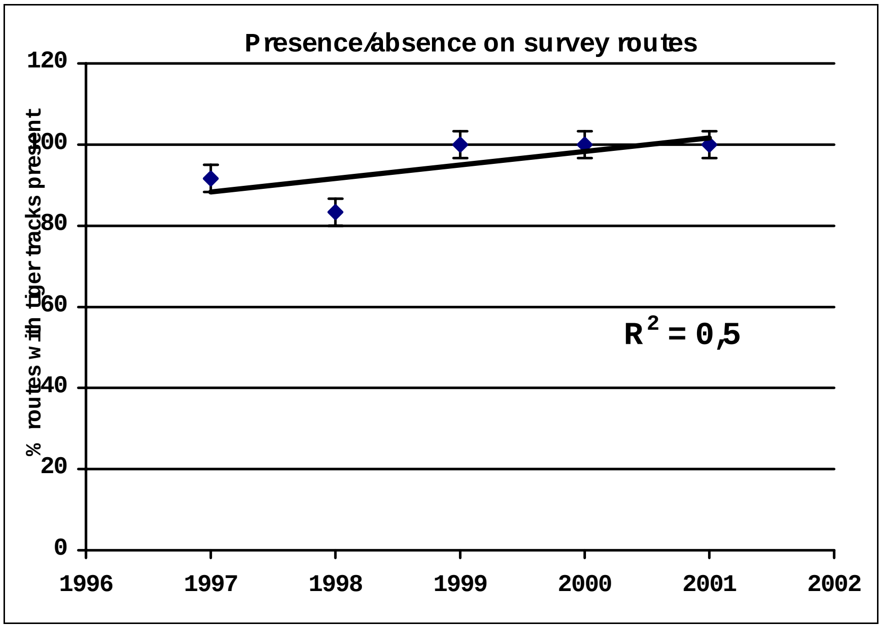
We can say that tigers do not stay constantly in the reserve territory. Special continuous observation showed that female with two cubs (more than 1 year old) and adult male and female can visit Petrov area (southwestern coastal part of the reserve) more rarely than once in a month. In previous years tigers were registered here constantly.

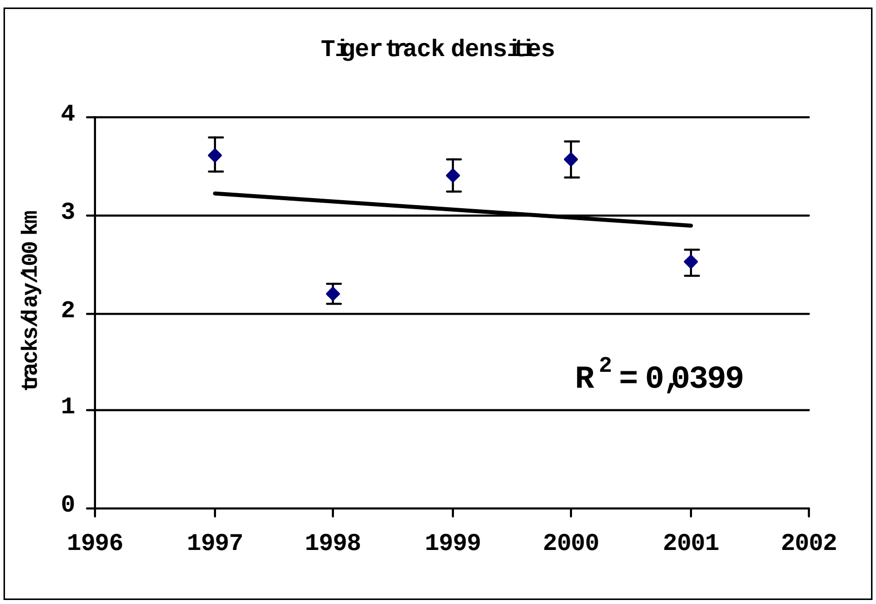
Therefore in spite of the fact that some tiger population characteristics improved the presence of tigers in reserve territory is not stable.

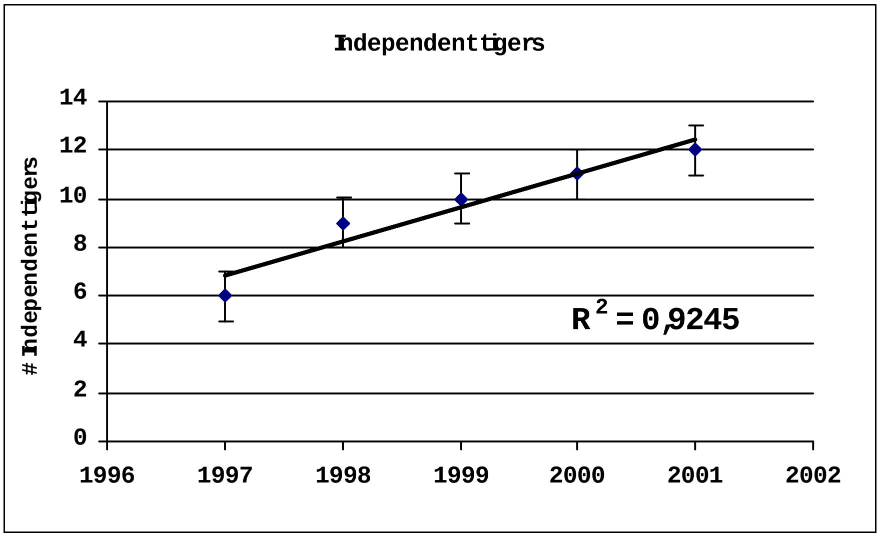
Status of habitats

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. 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.

Some hunting leases grow crops in areas near reserve borders (in order to attract ungulates here and then hunt for them. It affects ungulate densities and consequently tiger population in the reserve.


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
$R^2 = 0,5$


Tiger track densities
tracks/day/100 km
4
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
$R^2 = 0,0399$

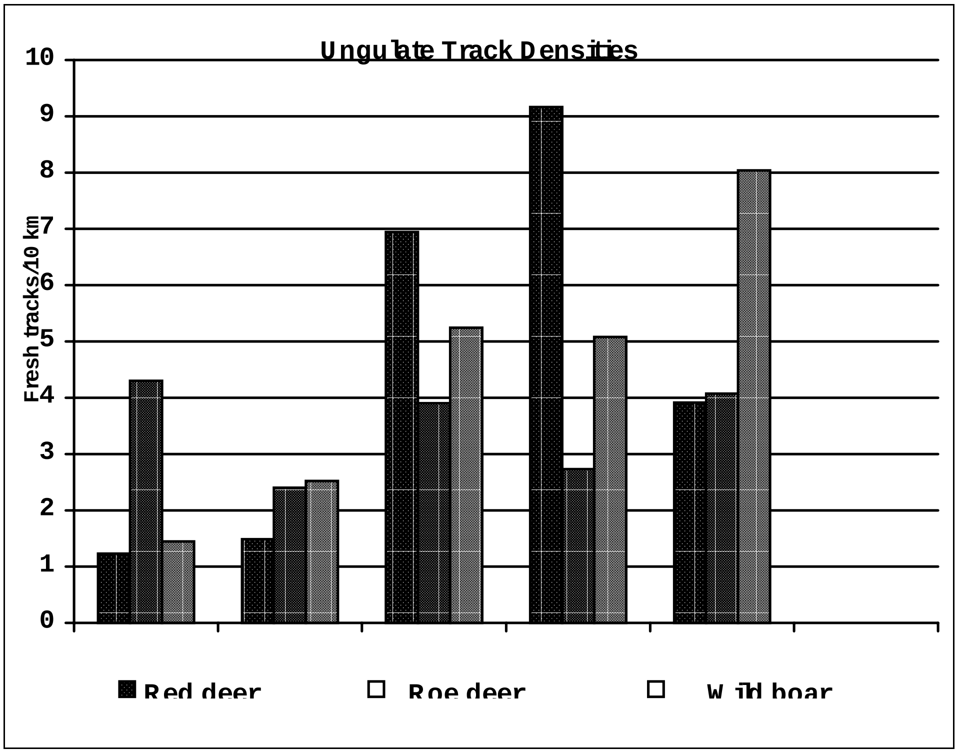


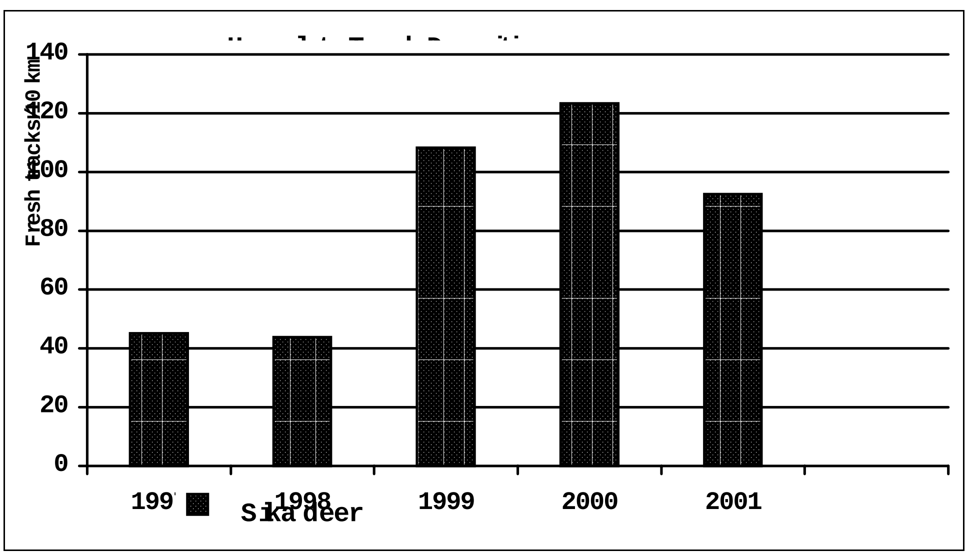
Number of tigers, by age class and sex (for adults only) in "Lazovsky Zapovednik" Amur tiger monitoring site

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

Mean track density (tracks less than 24 hours) of ungulates in "Lazovsky Zapovednik" Amur tiger monitoring site for 5 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
Total mean		4.55	10.31	3.48	6.04	82.63	111.52	4.47	9.63


Ungulate Track Densities
Fresh tracks/10 km
10
9
8
7
6
5
4
3
2
1
0
Red deer
Roe deer
Wild boar


Fresh tracks/10 km
140
120
100
80
60
40
20
0
1998
1999
2000
2001
Sika deer

LAZOVSKI RAION

Southeast Primorsky Krai

Report on results of Amur tiger monitoring program in Lazovsky Raion model unit in winter 2001-2002 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 simultaneous counts*: January 16-18 and February 18-25 (one survey route was traveled on 6th of March)
4. *Routes ##*: 1-11
5. *Total length of routes*: In January and February 9 routes were traveled on foot, 2 routes were partly traveled on foot and partly - by vehicle. Total length of routes covered in January is about 140 km and in February - about 130 km.
6. *Survey conditions*: this winter the first snow fell on December 13. Five routes were traveled 6-7 days after last snowfall and before the next heavy snowfall, which happened on January 7-8, 2002. Other survey routes were covered 4-7 days after the last snowfall. Before these heavy snowfalls snow depth on routes varied from 12 to 20 cm. Southern slopes were partly free of snow. After snowfall it became more difficult to travel along the routes. The snow was wet and soft, skies sank into snow 29-53 cm deep.

After heavy snowfall on January 7-8 snow fell several times more but did not cover all the tracks that were left after January 8. Therefore tracks left after this snowfall remained until survey in February that was conducted 32-39 days later. At that time snow depth varied from 20 cm on southern slopes on seashore to 150 cm in snowdrifts. During survey in February there was thaw that made traveling difficult. Counters could not cover one survey route at that time and returned to it on March 6.

7. *Assessment of efficiency*: Survey conducting was difficult due to heavy snowfall that happened in Primorye. At the time of first survey the weather was frosty and allowed estimating track age and making measurements. In February it was much more difficult to do this because of the thaw. By the noon snow melted to a great extent and tracks were melted and destroyed. Therefore it was impossible to make measurements and estimate age of the tracks. In February some routes were not covered completely.

Summarizing of 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. First snow fell in the middle of December. Heavy snowfall happened in early January. There was no hard frost and large parts of southern slopes were free of snow for a long time. All these conditions had to help ungulates to pass the winter easier than in previous year. In comparison with previous winter season total ungulate densities increased (wild boar and roe deer densities in particular). Sika deer density increased as well if counts in January are taken into consideration. Red deer density remains at low level. This winter deaths of ungulates were not observed. Four sika deer were poached, it is less than last winter. Hunting of feral dogs on sika deer were observed.
People continue hunting sika deer instead of red deer and roe deer that are not abundant here.

Status of tiger population in comparison with previous information (for example with data of Tiger census 1996).

Although the number of identified tigers was less than in 1996, the number of litters ran up to the level of winter season of 1996 and the number of cubs increased (5 in 1996 and 8 this year). What's more one litter remained from the previous year. Tigers began to be registered in southeastern part of model unit adjacent to densely populated Partizansky Valley. But tiger tracks encounter rate here as well as on survey route # 9 (not far from Chistovodnoe village) is lower than in winter season 1995-1996.

Hunting grounds on the seashore in Latviiskaya, Malaya ams Bolshaya Parkovaya valleys as well as in Obruchevka river valley are guarded by private forces (poachers are evicted, and persistent poachers are punished unofficially). Road to Melkovodnaya bay was closed before recreational base and vehicle can not pass through it. Water supply point was close down in Uspeniya bay, no workers stay here except watchman. This helps to ungulates and tigers conservation. Tiger litter, which was found here last year, still lives.

Status of habitats

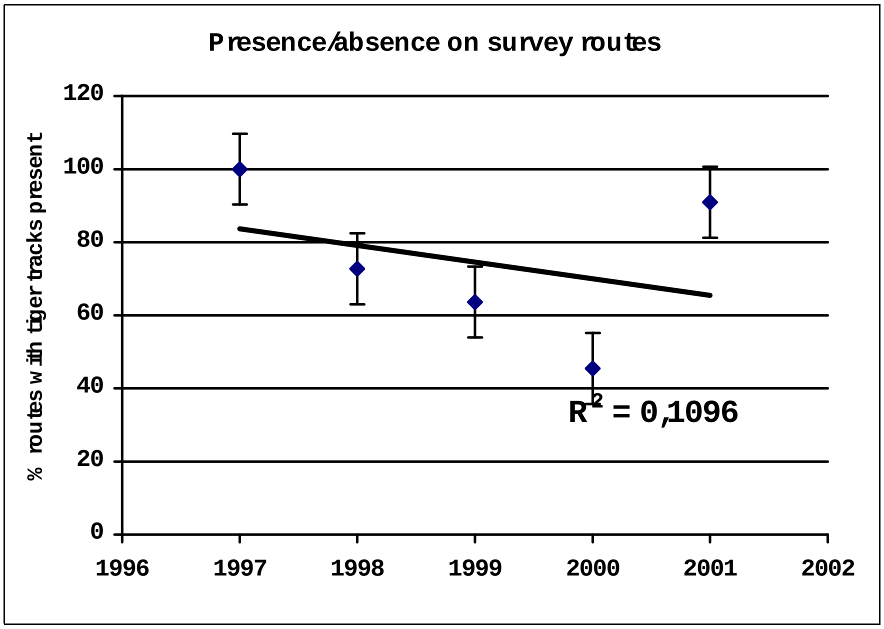
During this year, no considerable movements of human population happened in this model unit.

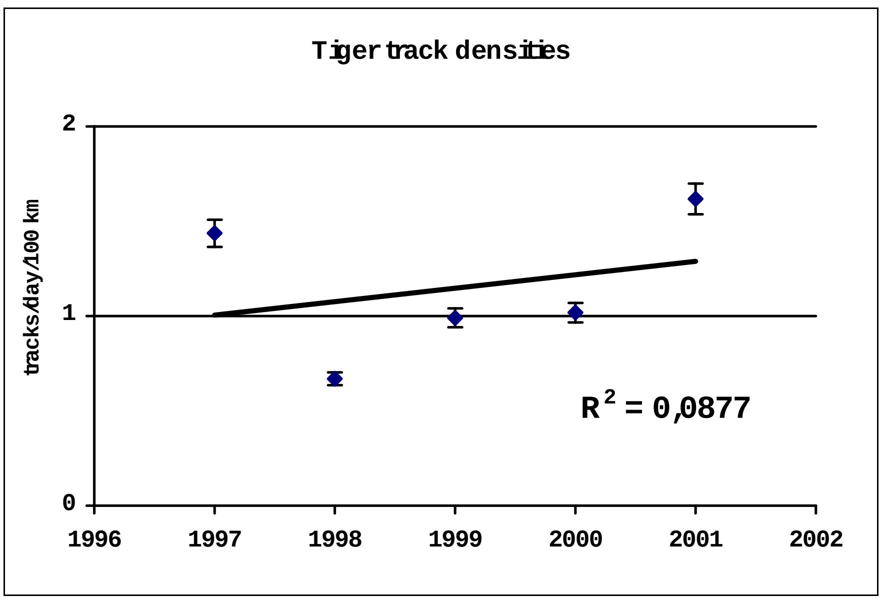
The number of wood-cutting sites as well as logging areas increased significantly. In this connection some roads were cleaned with bulldozer this year. In those parts of model unit, which are often visited by people, the number of ungulate tracks is significantly lower.

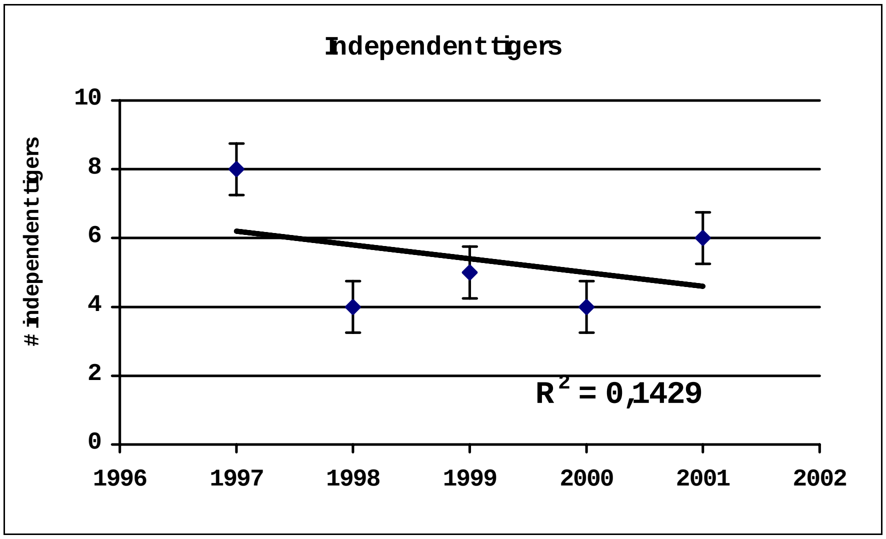
In fall loggers settled down in upper reaches of Polozov creek. Tiger killed their dog and repeatedly visited this place.

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 Partizanski raion in model unit remains high. In summer many people are looking for ginseng here.


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
R2 = 0,1096


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
R2 = 0,0877

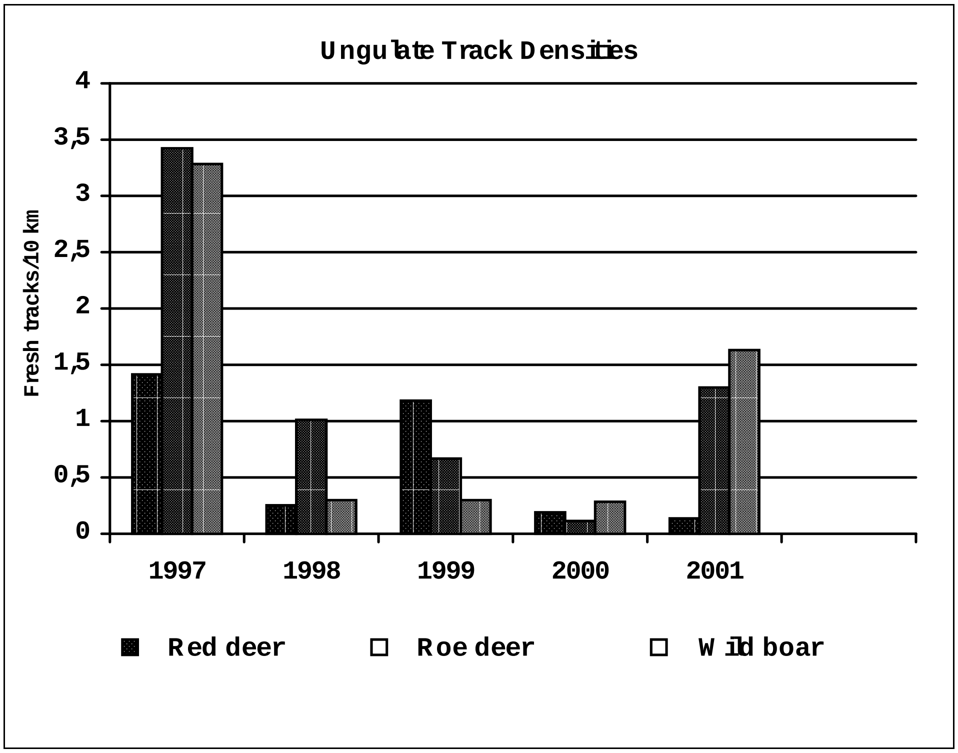


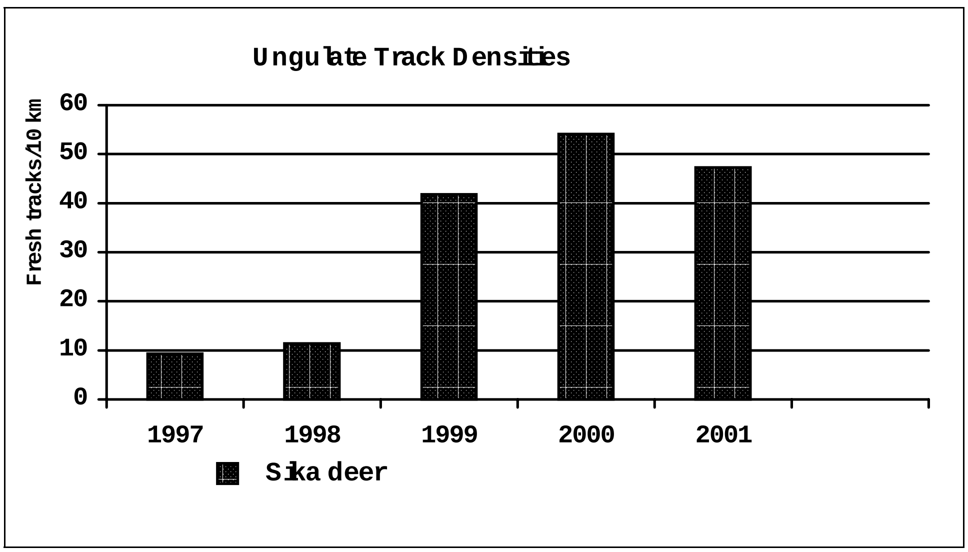
Number of tigers, by age class and sex (for adults only) in “Lazovsky Raion” Amur tiger monitoring site

	Age						Total		
	Adult								
Year	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

Mean track density (tracks less than 24 hours) of ungulates in “Lazovsky Raion” Amur tiger monitoring site for 5 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	0.30	0.67
1999	11	1.18	5.32	0.67	2.06	41.79	76.25	0.30	0.75
2000	11	0.19	0.68	0.11	0.52	54.10	117.39	0.28	0.87
2001	11	0.14	0.64	1.30	2.02	47.30	141.62	1.63	2.31
Total mean		0.63	2.22	1.30	2.71	32.79	72.43	1.16	1.40


Ungulate Track Densities
Fresh tracks/10 km
4
3,5
3
2,5
2
1,5
1
0,5
0
1997
1998
1999
2000
2001
Red deer
Roe deer
Wild boar


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

USSURIISKY ZAPOVEDNIK

South-central Primorsky Krai

Report on results of Amur tiger monitoring program in Ussuriisky Zapovednik model unit in winter 2001-2002 Coordinator - V.K. Abramov, Ussuriisky State Zapovednik

Assistant coordinators: Kovalev V.A. – Ussuriiski 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). Survey was conducted on 19-22nd of December and on 19-20th of February.

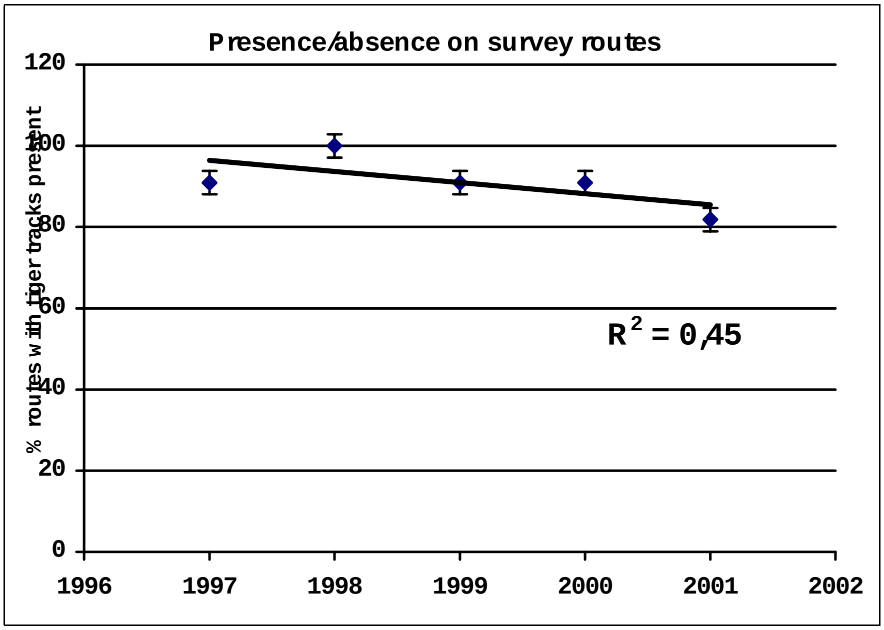
Survey conditions. In December 2001 snow depth depended on routes location. Snow was 5-7 cm deep along the roads, where tracks were measured, and in some forest areas snow was up to 10 cm deep. In February after heavy snowfall snow depth increased greatly up to 70-75 cm in some places. Snow depth in the most of areas varied from 45 to 60 cm.

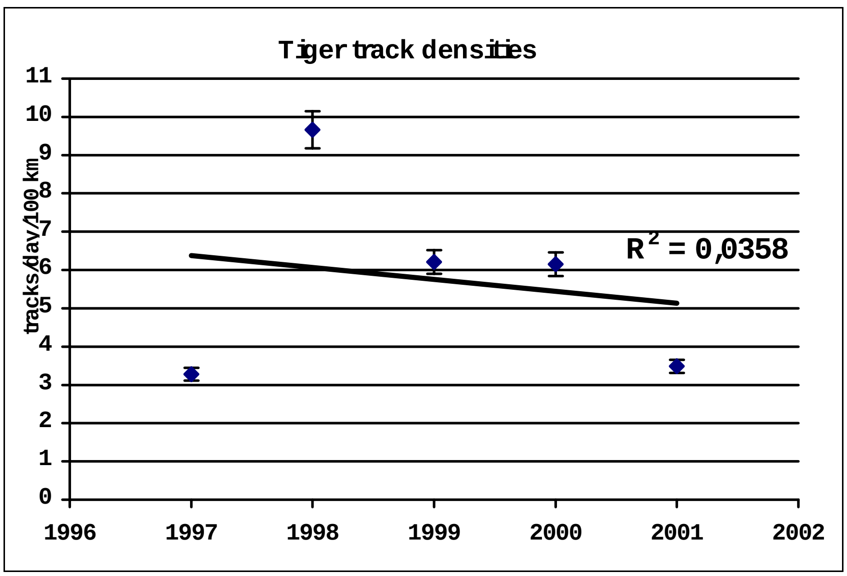
Survey efficiency (ungulate and tiger tracks encounter) was low. The main reason of this was heavy snowfall and concentration of animals on confined areas.

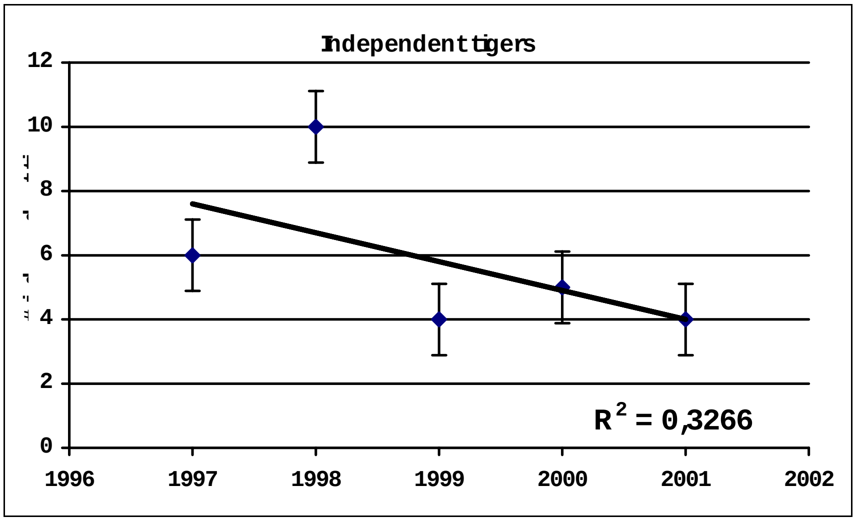
Sometimes it was very difficult to travel along the route by vehicle because the roads were not passable. As those road sections are situated in lowlands, they were not frozen and it was necessary to rent bulldozer or tractor to travel along such route.

It is necessary to provide additional funds for tractor rent and fuel to conduct the survey in the future.

Seven tigers were wintering in model unit in 2001-2002 winter season: one female with two cubs, two females without cubs and two males.


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
R2 = 0,45


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
R2 = 0,0358

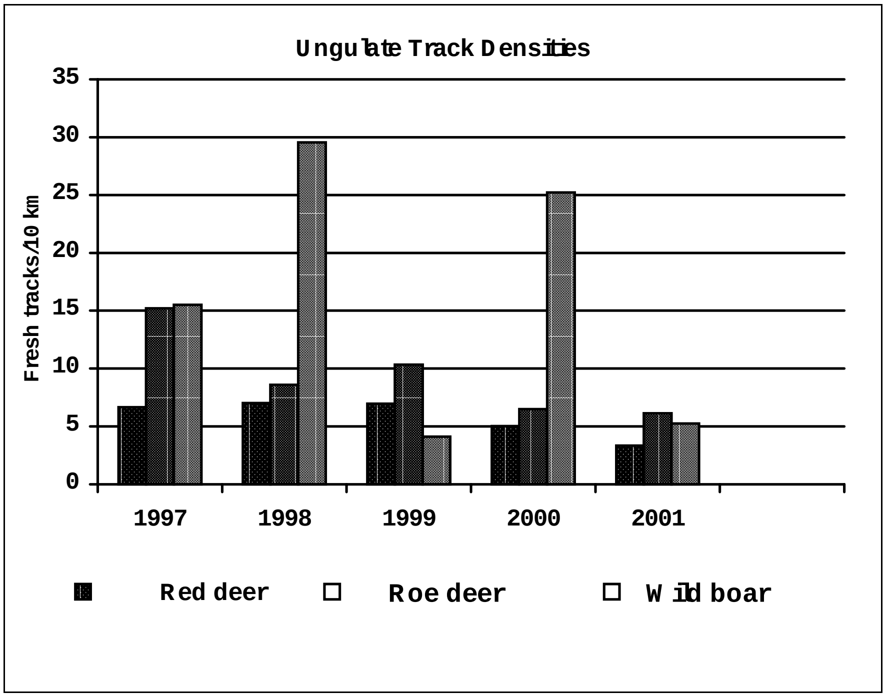


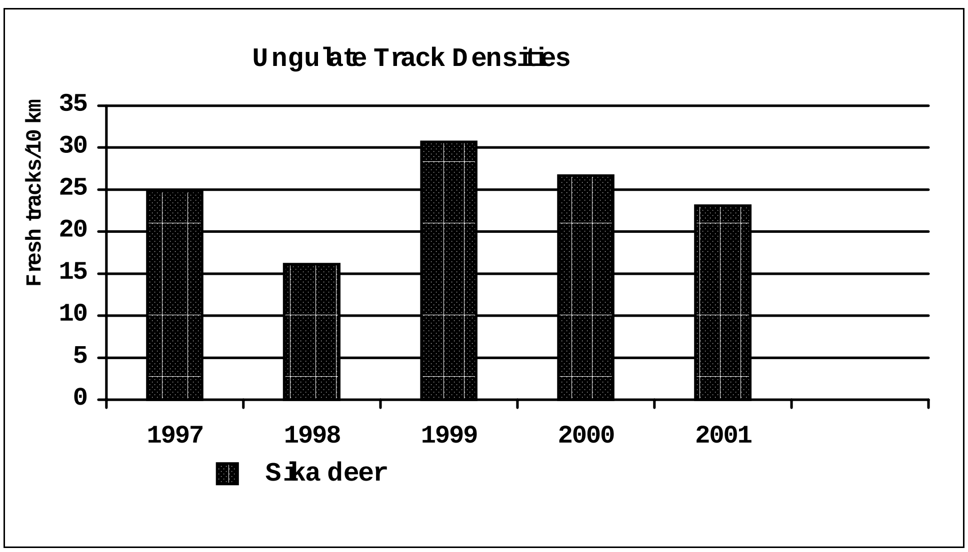
Number of tigers, by age class and sex (for adults only) in "Ussuriisky Zapovednik" Amur tiger monitoring site

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

Mean track density (tracks less than 24 hours) of ungulates in "Ussuriisky Zapovednik" Amur tiger monitoring site for 5 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	15.20	20.08	24.81	28.54	15.50	20.55
1998	23	7.03	7.25	8.61	11.31	16.12	19.58	29.56	35.20
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
Total mean		5.81	7.11	9.35	11.07	24.28	32.31	15.93	21.58


Ungulate Track Densities
Fresh tracks/10 km
35
30
25
20
15
10
5
0
1997
1998
1999
2000
2001
Red deer
Roe deer
Wild boar


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

IMAN

Central Primorsky Krai

Report on results of Amur tiger monitoring program in Iman monitoring unit in 2001-2002 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 in December 27-29, 2001 and in February 17-25, 2002.

In December total length of routes traveled by vehicle is 131 km, on foot - 67. In February total length of routes traveled by vehicle is 92 km, on foot - 82 km, by snowmobile - 24 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 19 cm and 35 cm correspondingly; in February - 41 cm and 60 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 count in December took place on December 13 and snowfall before count in February - on February 18. Therefore, it had not been snowing for 14 days before first count and for 4 days before the second count.

This winter season as well as previous one was unfavorable for local tigers. The reason is predator-prey imbalance. Among tiger prey species first of all it concerns wild boar - its density has been remaining at the lowest level for the past seven years.

Status of red deer and roe deer populations can be estimated as satisfactory.

It's necessary to mention that tiger prey species were more abundant this year in comparison to previous one. This winter season some increase of red deer, wild boar and roe deer numbers was observed. Ungulates concentrated in the middle reaches of Orekhovka and Gornaya rivers. Due to this fact tiger migrations within the unit also changed. For example, during previous years we usually registered tiger tracks on the 1st route (upper reaches of Orekhovka river) and this winter season we did not found tiger tracks there. Probably they moved from upper reaches to middle reaches, where ungulate densities were high and density of tiger tracks here was relatively high as well.

Due to deep snow conditions for tigers and prey species were extremely heavy in the second half of winter. They could not move and almost stood at one place, especially ungulates. Home ranges of red deer and roe deer shrank to several hundred meters in diameter. Reduced ability of ungulates to move is confirmed by fresh tracks encounter rate in December and February (see table 1).

Table 1. Encounters of fresh ungulate tracks within model unit

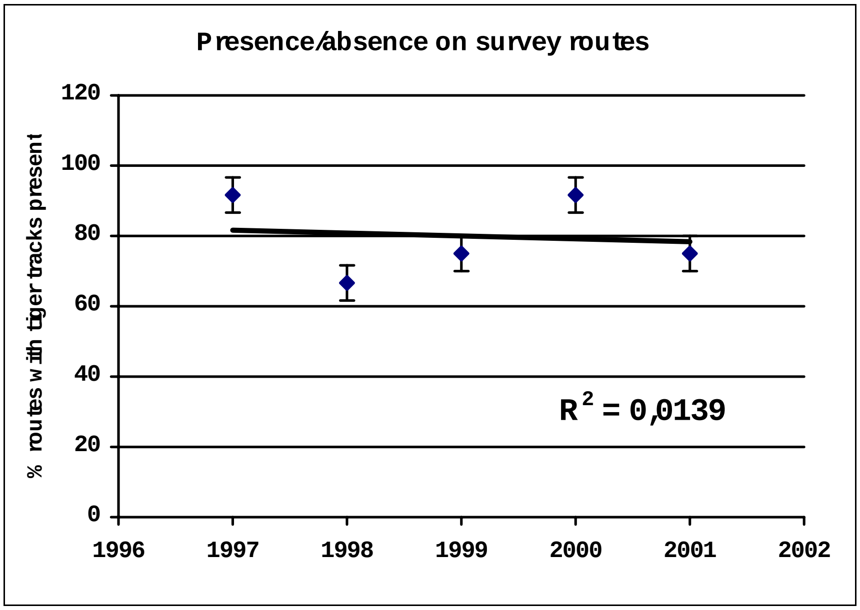
1st count (December 27-29, 2001)			2nd count (February 17-25, 2002)		
Red deer	Wild boar	Roe deer	Red deer	Wild boar	Roe deer
171	82	117	102	20	43

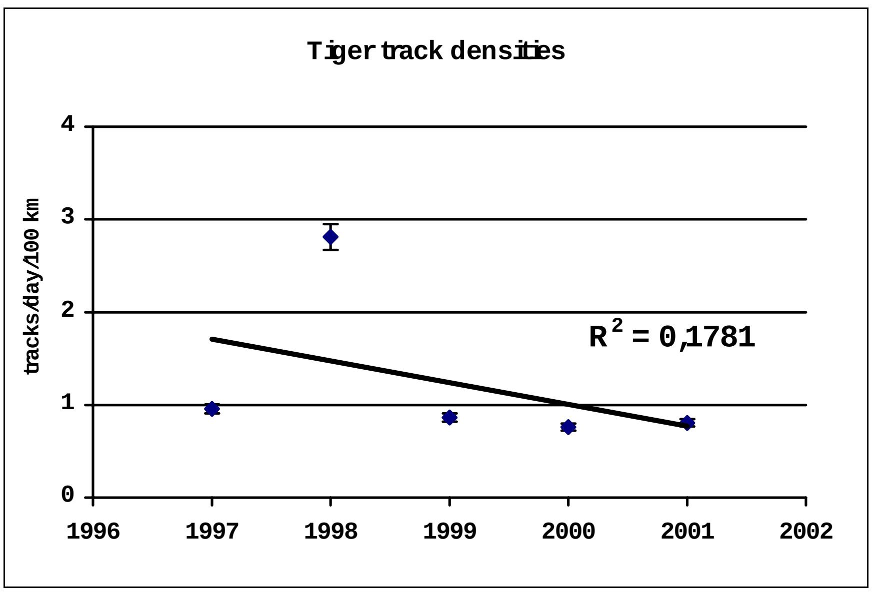
The same can be supposed about tiger movements. In December 21 tiger tracks were found in survey routes, and in February only 6 tiger tracks were registered. This can explain why female and a cub, which were found in December, were not registered in February.

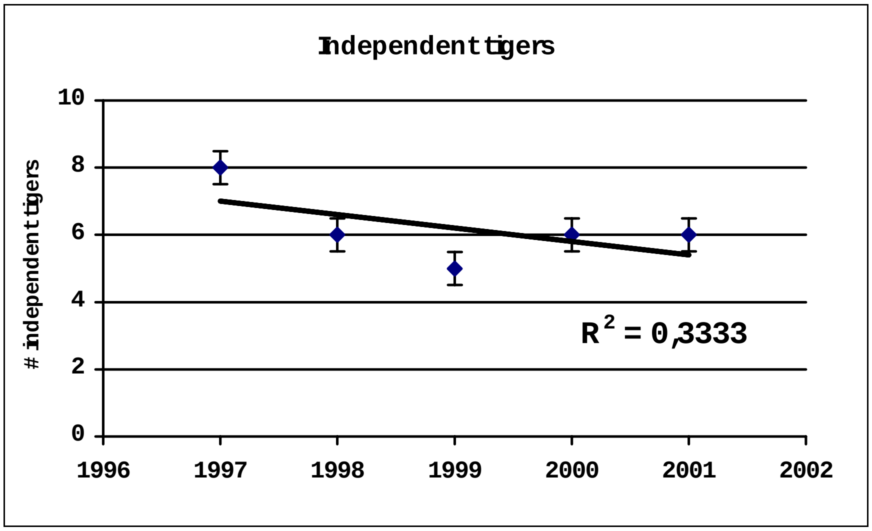
The second (after prey species status) important negative factor is human disturbance. The role of this factor has increased due to the more intensive logging. Logging activity increased mostly due to different industrialists and illegal logging. This factor affects females with cubs most of all. They 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 very high as in previous years.

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


Presence/absence on survey routes
% routes with tiger tracks present
0
20
40
60
80
100
120
1996
1997
1998
1999
2000
2001
2002
R² = 0,0139


Tiger track densities
tracks/day/100 km
0
1
2
3
4
1996
1997
1998
1999
2000
2001
2002
R² = 0,1781

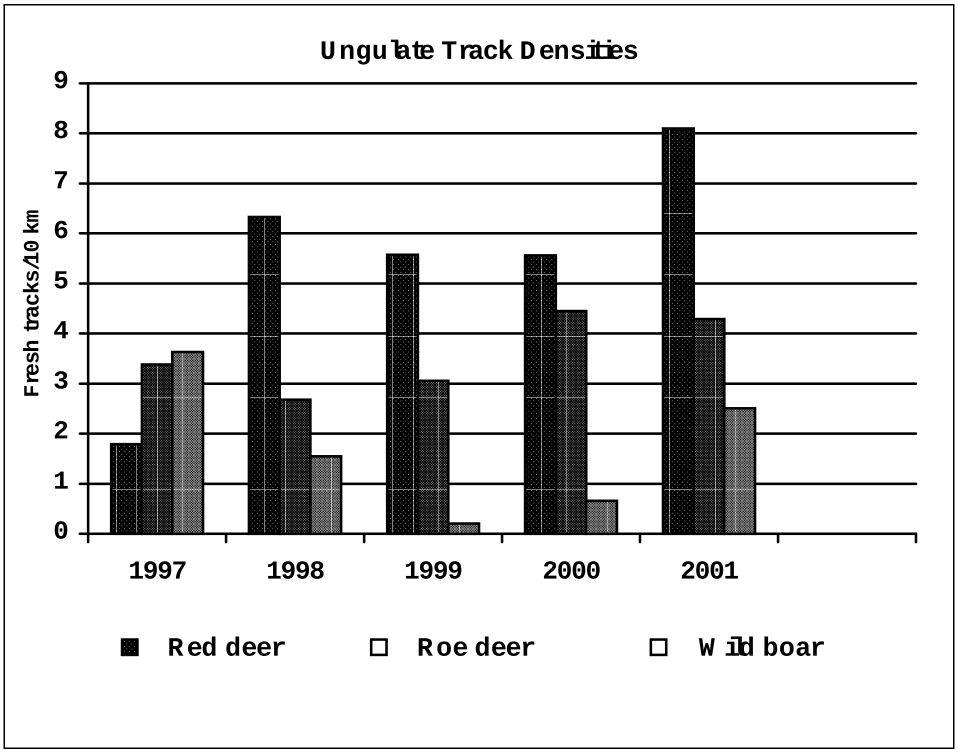


Number of tigers, by age class and sex (for adults only) in “Iman” Amur tiger monitoring site

Year	Age: Adult: Males	Age: Adult: Females	Age: Adult: Unknown	Age: Subadult	Age: Cubs	Age: Unknown age	Total: Total adult tigers	Total: Total independent tigers	Total: 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

Mean track density (tracks less than 24 hours) of ungulates in “Iman” Amur tiger monitoring site for 5 years

Year	n	Red deer mean	Red deer SD	Roe deer mean	Roe deer SD	Sika deer mean	Sika deer SD	Wild boar mean	Wild boar SD
1997	12	1.79	3.06	3.38	5.55	0.00	0.00	3.63	5.23
1998	12	6.33	7.91	2.68	2.63	0.00	0.00	1.55	3.15
1999	12	5.58	7.67	3.05	5.47	0.00	0.00	0.20	0.60
2000	12	5.56	5.61	4.45	6.98	0.00	0.00	0.66	2.89
2001	12	8.10	6.49	4.29	7.68	0.00	0.00	2.51	4.36
Total mean		5.47	6.15	3.57	5.66	0.00	0.00	1.71	3.25


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

BIKIN

Central Sikhote-Alin, Northern Primorsky Krai

Report on results of Amur tiger monitoring program in Bikin monitoring unit in winter 2001-2002
Coordinator - D.G. Pikunov, Pacific Institute of Geography, Far Eastern Branch Russian Academy of Sciences

Bikin model unit is situated in the basin of middle reaches of Bikin river, nearly 40 km north from Krasny Yar and Olon settlements. From the west model unit is limited by new main road from Khabarovsk, which crosses Bikin river. Eastern side, partly included in model unit, is limited by forests, where intense commercial logging took place during past 20 years (for the first time primary pine-broadleaved forests were cut down). The left bank of Bikin river and right bank above Amba river basin are covered with primary pine-broadleaved forests, where logging never took place. Road network is absent here. The only road for traffic is frozen Bikin river in winter, there is a snowmobile road along the river up to Ochotnichiy settlement (and in some years farther). In summer motor-boats are used for moving along the river.

The results of Amur tiger sweep surveys conducted in 1978-1979 and in 1984-1985 indicated one of the highest densities of tigers in Bikin river basin, which was nearly equal to tiger densities in Sikhote-Alin and Lazovsky Reserves (Pikunov et al., 1983; Pikunov, 1988).

Amur tiger census, conducted in 1995-1996 (Matyushkin et al., 1996) and subsequent monitoring in model unit proved Bikin river basin to be one of the main habitat for the Amur tiger in Sikhote-Alin.

Conditions and time of survey. The first survey was conducted in model unit as usual shortly after New Year holidays. By this time river is already frozen and local hunters made new snowmobile trail along the river. In December this model unit is not accessible. In 2002 the first survey was conducted from January 4 till January 12. The weather was favorable - there were no heavy snowfalls during the survey. It allowed us to conduct the survey in a very short time. Snow cover was 20-30 cm deep and it allows traveling along survey routes on foot and deep-frozen river was suitable for safe moving along the river by snowmobile. Working group consisted of 5 people as in previous years, including two aboriginal professional hunters. They have a good knowledge of the territory, tracks and behavior of wild animals and can drive snowmobile.

Snow cover was not evenly distributed across the model unit. Snow depth varied from 10 to 30 cm in survey routes # 5, 7, 14, 15. Maximum snow depth (30-40 cm) was in routes # 6, 9, 10, 11.

The second survey was conducted from February 12 to February 21, 2002. Average snow depth varied from 40 to 60 cm. In addition heavy snowfall happened between 19 and 20 of February and according to the "Instruction for coordinators" we stopped our work. It made difficult travelling along the routes and river, where ice mounds and scours formed, that made using of snowmobiles dangerous.

16 routes were covered during both surveys, the total length of routes covered is 210-215 km (the length was determined by curvimeter). As in previous years routes # 1, 2, 10, 11 were traveled by snowmobile and the total length of these routes was about 60 km. Other routes were covered on skies. During both surveys there was no icy crust over snow - neither in riverine forests nor on slopes of different aspects. The lack of pine nuts and acorns was the possible reason why ungulates concentrated in river valley and in its tributary valleys. There ungulates fed upon horse-tail and twigs of different trees.

Status of ungulate populations

Red deer. This is the most common prey species of Amur tiger in the Bikin model unit. Despite intensive hunting in this most accessible part of Bikin river basin red deer density here is high enough and what's more important it is stable. During the first survey red deer track encounter rate was 5.9 fresh tracks per 10 km of survey routes, during the second survey - 3.6. Therefore across the model unit average encounter rate was 2-3 red deer per 10 km of survey routes. Slight increase of red deer numbers was registered in northwestern part of the model unit.

Wild boar. Its density remains low as in previous years: during the first survey track encounter rate was less than 2 tracks per 10 km of survey routes (1-1.5 individuals), during the second survey it was even less - one track (0.71 individuals) per 10 km of survey routes. Few wild boar litters were registered across the model unit - mostly in basins of left tributaries of Razvilistaya and Klenovka rivers. Maximum number of tiger tracks was registered here during both surveys.

Local aboriginal hunters suppose that the main reason of low wild boar density (which is not typical for this area) is the absence of pine nuts harvest during past 6 years and poor harvest of acorns during many years. This issue requires special ecological investigation. No doubt that poor harvest (or lack of harvest) of main fattening forage has negative impact on all ungulate populations.

Roe deer. This is the common prey species of tiger in Bikin model unit. Its density is stable and even high in some parts of the territory. Average encounter rate is 3-5 fresh tracks (2-3 individuals) per 10 km of routes. During the second half of winter after heavy snowfalls roe deer concentrated in riverine forests and lower reaches of Bikin tributaries as well as in Bikin river valley.

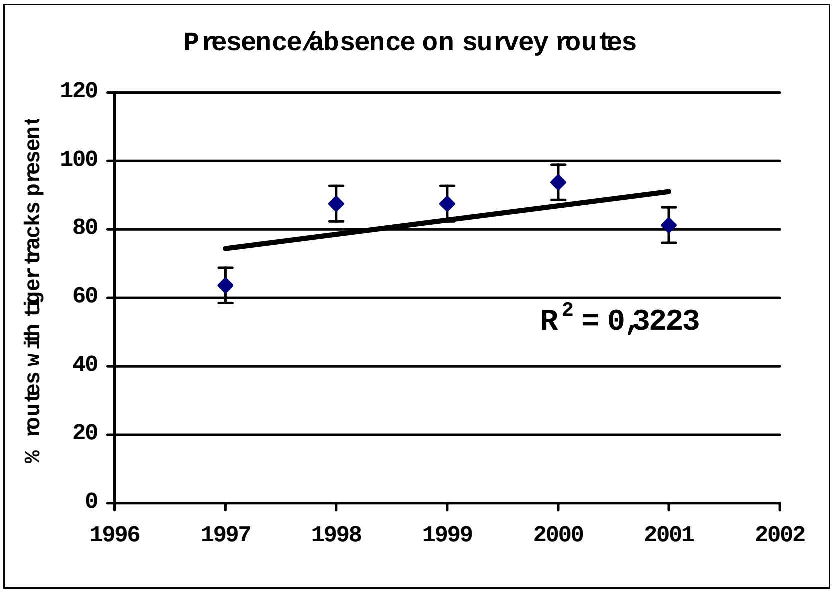
Amur tiger population status. In comparison with the results of previous surveys tiger numbers increased slightly. Tiger tracks were registered on 14 routes out of 16 (87,5%). It is necessary to mention that this winter trophic conditions were far from favourable for predators. The reason is low density of wild boar and very few wild boar litters. Young tigers are not able to kill adult wild boar or red deer. Nevertheless tiger can find 8-13 fresh ungulate crossings per 10 km of survey routes. This encounter rate is nearly twice higher than in model units in Khabarovski krai. Tiger litters in Bikin model unit (one in Amba river basin, and another (broken up by the time of survey) in Otrogovaya and Klenovka river basins) are the evidence of normal habitat condition even in this most developed and visited by hunters area of Bikin river basin.

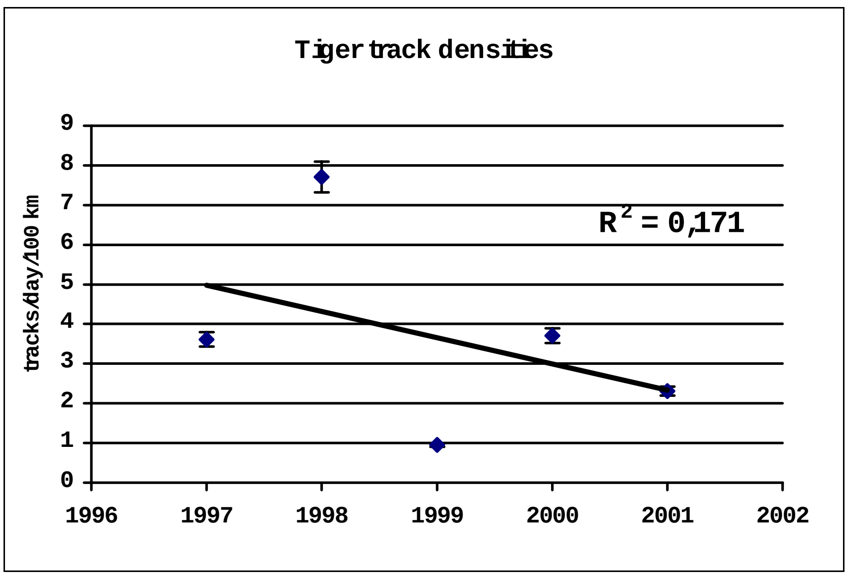
After wild boar rutting season ended and deep snow cover formed by the time of the second survey ungulates stopped moving actively (the other reason of less active movements of ungulates is their lowered density due to hunting and predation) and tigers became more active. During the first survey when encounter rate of ungulate crossings was 13-14 tracks per 10 km, tiger tracks were found only on 7 routes (43.8%). When encounter rate of ungulate crossings decreased to 8 tracks per 10 km, tiger tracks were found on 11 routes (69%). The number of tiger crossings increased from 14 to 20.

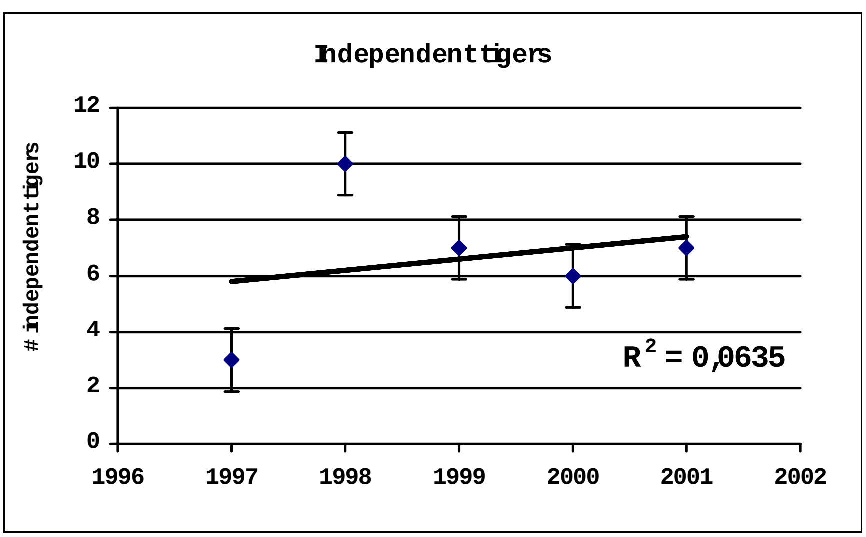
According to the information obtained from professional hunters, working in upper basin of Bikin river (Okhotnichiy settlement area and north, 150-200 km from model unit), there was little snow there (even by the end of winter snow depth did not exceed 20-30 cm) and there was very high density of wild boar and numerous litters were found. Especially significant increase of wild boar numbers was registered by professional hunters during December 2002 (i.e. during wild boar rutting season). Wild boar density remained high (10-15 individuals per 1000 ha) here till the end of winter. Hunters mentioned that along with increasing of wild boar density the number of tigers also increased. We have reliable information about adult tigers, which moved from eastern slopes of Sikhote-Alin to this area (Chainy creek, Biamo river). In addition, wolf tracks together with tiger tracks were found along rivers and creeks, that was extremely rare in previous years.

Thus the following tigers were registered in Bikin model unit in winter 2002: 2 resident males, two adult females, one female with two cubs, one young tiger and one tiger of undetermined sex and age. 6-7 tigers in total, that means 0.5-0.6 tigers per 10 000 ha of forested area.

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


Presence/absence on survey routes
% routes with tiger tracks present
120
100
80
60
40
20
0
1996
1997
1998
1999
2000
2001
2002
R2 = 0,3223


Tiger track densities
tracks/day/100 km
9
8
7
6
5
4
3
2
1
0
1996
1997
1998
1999
2000
2001
2002
R2 = 0,171

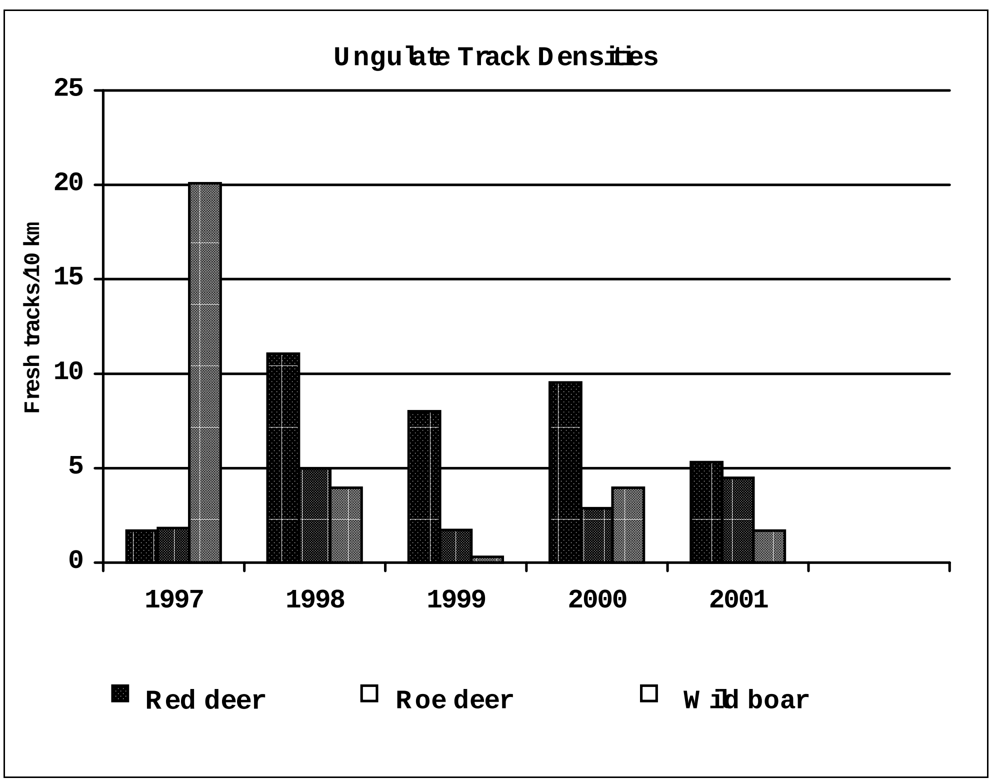

Independent tigers
independent tigers
12
10
8
6
4
2
0
1996
1997
1998
1999
2000
2001
2002
R2 = 0,0635

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

Mean track density (tracks less than 24 hours) of ungulates in "Bikin" Amur tiger monitoring site for 5 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	0.00	0.00	20.09	94.01
1998	16	11.07	12.49	4.98	6.29	0.00	0.00	3.96	6.88
1999	16	8.01	9.48	1.74	3.57	0.00	0.00	0.30	0.84
2000	16	9.53	11.63	2.88	4.31	0.00	0.00	3.97	7.50
2001	16	5.32	6.70	4.49	6.06	0.00	0.00	1.69	2.73
Total mean		7.12	8.46	3.18	4.61	0.00	0.00	6.00	22.39



BORISOVSKOE PLATEAU

Southwest Primorsky Krai

Report on results of Amur tiger monitoring program in Borisovskoe Plateau monitoring unit in winter 2001-2002

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

Southwestern part of Amur tiger range is isolated from Sikhote-Alin part of range. Till 1970-s tigers inhabiting this area and northern provinces of China represented single tiger subpopulation. After border construction line (BCL) was built in 1979 contacts of tigers from Russia with tigers from Jilin and Heilongjiang provinces (China) became much more difficult. According to information from border guards such contacts are rare – only some individuals do it occasionally.

Long-term field investigations, which began in 1960-s and continue after border line construction, show that in winter ungulates gather along BCL only on Chinese territory. This information is confirmed by numerous ungulate tracks found to the west of the BCL. Probably this is the reason why moving of individual tigers through BCL, from Russia to China, is common. It is confirmed by our field observations and by information from border guards. Results of our surveys conducted in northeastern provinces of China in 1998 and 1999 confirmed that tiger numbers here is extremely low and most of registered tigers were found near international border. Based on this data and our long-term investigations in southwestern Primorye we can state confidently that we can’t rely on afflux of tigers from China to Russia. During last years the situation is absolutely different – tigers move from Russia to China. That’s why small tiger subpopulation in southwestern Primorye (including Borisovskoe Plateau) requires careful attitude – today this is the only source of tigers for dispersing into northeastern territories of China. Therefore monitoring of status of tiger population and ungulate populations in Borisovskoe Plateau, which is situated near most densely populated areas of Primorye, is very important and timely.

Conditions and time of surveys. We shifted the time of the first survey due to weather conditions. We cannot conduct the first survey in Borisovskoe Plateau in December because the territory was free of snow. The survey began only on the 18 of January, except route # 3, which was traveled on 6th of January. Snow depth on this route was 3-5 cm deep, and snow cover was present only on plateaus and northern slopes. Heavy snowfall began on 20th of January and stooped on 22nd of January. Snow depth in some areas of upper and middle parts of river basins increased up to 80 cm and more. Survey was resumed on 24th of January. It was very difficult to travel along survey routes and we had to investigate other routes by our own strength. We could not hire specialists (egers) from hunting leases and zakazniks because they were not able to use skies for traveling along the routes. As a result several routes were not covered completely: route #5 (upper Elduga) 6 km out of 12 were covered, route # 6 (Malaya Elduga) 8 km out of 15 were traveled, route # 10 (Pervaya Rechka) - 8 km out of 15 were covered (route length was determined with curvimeter), route # 12 (Malaya Kedrovka) was not covered at all. Some routes, which were normally covered by vehicle completely or partly (routes along Sanduga, Malaya Elduga, Pervaya Rechka, Vtoraya Rechka, Bolshaya and Malaya Kedrovka) were not passable—even for GAZ-66, which was rented specially for this purpose. Total length of all routes covered was 180-190 km versus 230-240 km planned.

When snow depth is not extreme routes ## 4, 7 and 12 are covered by GAZ-66; routes ## 1, 2, 6, 9 and 10 are covered partly by vehicle and partly on foot; routes ## 3, 5, 8, 11 and 14 are always covered on foot (skies). This year using of snowmobiles in Borisovskoe Plateau was impossible on most routes because of warm winter and consequently partly unfrozen rivers and ice mounds. After heavy snowfalls in January the situation changed sharply - all routes, except routes # 4 and partly # 5, became passable on skies only. Many routes were dead-end: counter had to start travelling early in the morning, cover the route and return the same way in the darkness (there are no cabins for over-night stop in this territory). It is a very hard job because most routes were covered by counters single-handed. As a result some routes during the first survey were not covered completely.

The second survey was conducted in a very short time - from March 1 through March 6. Only route # 3 (Penyazhinsky) was covered on March 11 due to several reasons. All 14 routes planned to be traveled in Borisovskoe Plateau were covered completely. Route length varied from 10 to 20 km, and average length was 12-17 km.

During the second survey the data on distribution, numbers and death of wild ungulates was obtained. Total length of routes covered by vehicle was 85-90 km, other routes (total length was 140-150 km) were covered on foot (skies). By the time of the second survey snow had settled and covered with hard icy crust. Snow depth varied greatly in different places of Borisovskoe Plateau. In lower river basins snow depth was 5-25 cm, middle basins and flood-plain complex - 25-40 cm, in upper river basins - 50-60 cm. Especially hard icy crust over snow was observed in mountainous plateaus, where snow depth varied from 40 to 50 cm. Fresh crossings of ungulates and tigers were not found in secondary forests (without coniferous trees) of lower river basins and plateaus in the eastern part on monitoring unit. Thus during extremal winters with great snow depth secondary forests of lower river basins are not suitable for ungulates and predators.

Status of ungulate populations

Wild boar. Wild boar abundance is extremely low - 1-1.6 tracks per 10 km of survey routes during the 1st survey and 1.66 tracks during the 2nd survey. Slight increase of wild boar numbers was observed in upper river basins and western part of monitoring unit (pine and fir-spruce forests on plateaus and southern slopes). Probably wild boar population was underestimated, because 85% of routes were set along river valleys (flood-plain complex). In previous years before sika deer numbers reached its peak (mid-1970s) most part of wild boar population collected/gathered in valleys and northern slopes during the second part of winter. Here wild boars fed upon their favorite food - horsetail. After horsetail was consumed by sika deer herds wild boars did not stay in valleys and visited them rarely. It is evident that wild boars number in Borisovskoe plateau is so low (even in comparison with two previous winters) that this species does not play a significant role in tiger diet now.

Roe deer. During the 1st survey 312 roe deer crossings were registered on survey routes (16.86 tracks per 10 km of route). During the 2nd survey roe deer numbers decrease greatly. Only 37 crossings (1.54 tracks per 10 km) were registered. In winters with deep snow roe deer in Borisovskoe Plateau always move from upper river basins to lower reaches. Time of this migration always coincides with time of heavy snowfalls (after which snow depth was 50 cm and more). If in early winter rivers were open (???) then after heavy snowfalls animals moved down along river-beds. At that moment they were easy target for hunters.

During the 1st survey 90% of roe deer was registered in lower river basins. Great decrease of roe deer numbers by the time of the 2nd survey means that significant part of the population died. The reasons are deep snow and great energy expenditure during attempts to find food as well as legal and illegal hunting. Roe deer concentrated in lower river basins during heavy snowfalls in January were shot by the end of hunting season. During the 1st survey many sites where roe deer were shot were found in valleys of river lower reaches - 8 sites in Elduga, 10 in Sanduga and 6 sites in Vtoraya Rechka. Intensive poaching continued after the hunting season had been closed. Poaching took place mostly at the dark period of the day using vehicles equipped with automotive head lamps, because this is when roe deer gathered on roads cleaned off snow or near them in river lower reaches.

No increase of tiger numbers was registered in areas where roe deer were gathered. Probably predators do not follow the roe deer migration, and intensive human disturbance, associated with numerous roads and settlements situated in lower river basins, is the main obstacle for predators to stay here. Thus, roe deer is only the secondary prey species for tiger in Borisovskoe Plateau last years.

Sika deer. The behavior of sika deer in winters with extreme deep snow is very typical for this species. With the beginning of heavy snowfalls most part of population moves down from plateaus and slopes to valleys (flood-plain complex). Unlike roe deer sika deer do not move to lower river basins. In confined areas of such flood-plain complexes in the absence of human disturbance sika deer density can reach 50-70 individuals per 1000 ha. Such sika deer density is observed in fixed areas. For a long time (from early 1980-s) areas, where sika deer gather in high densities are stable and located in upper basins of Bolshaya and Malaya Elduga, Sanduga (Nezhinka), Vtoraya Rechka, Gryaznaya and in the western part of Barsovy Zakaznik, which is included in Borisovskoe Plateau monitoring unit. Main places of sika deer concentration are located in Borisovskoe Plateau Zakaznik, westernmost part of Nezhinsky Hunting Lease and in Barsovy Zakaznik as mentioned above. During winter season with deep snow significant pat of sika deer population - females with young first of all - prefer staying in valleys. After they had moved from plateaus and slopes they are not able to return back if snow cover is more than 50-70 cm deep. In valleys they stay for a long time depending on weather conditions. Sika deer leave valleys only when southern slopes are free of snow.

During the 1st survey 503 fresh tracks of sika deer were found on 185 km of survey routes (27.2 tracks per 10 km). During the 2nd survey 634 fresh tracks of sika deer were found on 240 km of survey routes (26.4 tracks per 10 km).

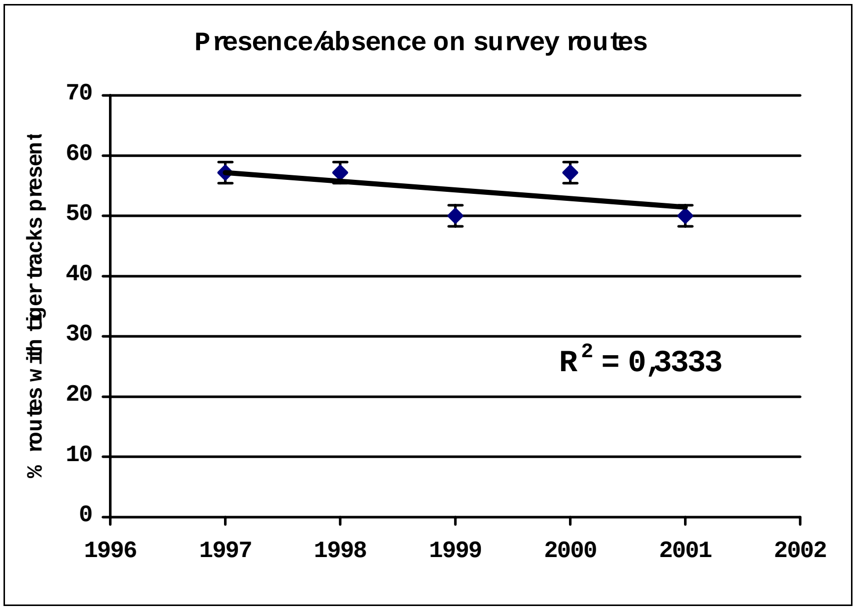
In areas with high density of sika deer during the 2nd survey 38 dead sika deer and 6 roe deer were found. All dead sika deer were found in areas of high sika deer concentration - on routes # 5 (upper Elduga), # 6 (Malaya Elduga), # 8 (upper Sanduga), # 9 (Vtoraya Rechka). On plateaus, where only 10% of survey routes were set and mainly adult part of population was registered, 5% of all dead animals were found. Only adult dead animals were found here. 95% of dead animals found in areas of deer concentration in valleys were young individuals born this year. Animals died in their beds near the river. Here numerous big piles of excrements were found that means that animals stayed here for a long time and fed on roughage poor in calories. Often near the dead animal there were one-two young sika deer, which hardly could move and were going to die. Bark were almost completely eaten from the trees there was an impression that deer ate everything including wormwood and dry branches. Young animals, which were not able to follow herds of adult deer, died. Young individuals left in places, where herd stopped for a while, in river and creek valleys.

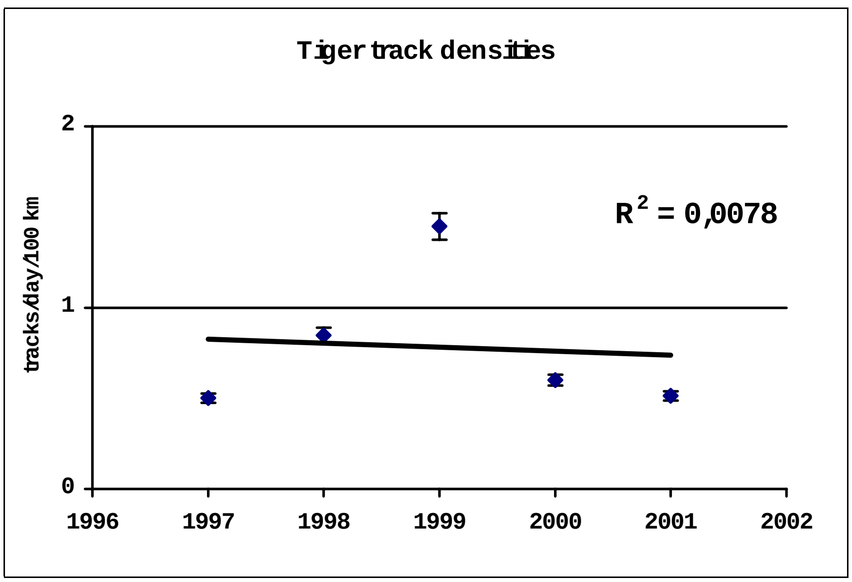
During the 1st survey just after heavy snowfalls dead sika deer were not found at all. All dead animals mentioned above were found during the 2nd survey conducted from March 1 through March 6. During unplanned repeated traveling along route # 5 on 19th and 20th of March 28 dead animals were found (on 2nd of March only 12 dead sika deer were found). At that time southern slopes were already free of snow. Therefore animals we found died in the second half of February. And probably other animals mostly died in early March. Unfortunately additional forage for animals provided in Nezhinsky hunting lease was ineffective. The reasons are as follows: 1. Feeding sites were organized late - mostly in late January and early February. 2. Forage was put in accessible sites - along roads and wood-cutting areas - but not in areas with high density of sika deer. Animals, which were staying in confined areas, could not find feeding sites (unlike roe deer they do not move along valleys). 3. Of all additional forage twigs of deciduous trees (ash, willow and poplar) were eaten mostly, silage was eaten to the less extent and rough hay (reed), which was provided along the roads in plenty, was not eaten at all. It was unnecessary to organize feeding sites near logging units, where deer can find different twigs in plenty.

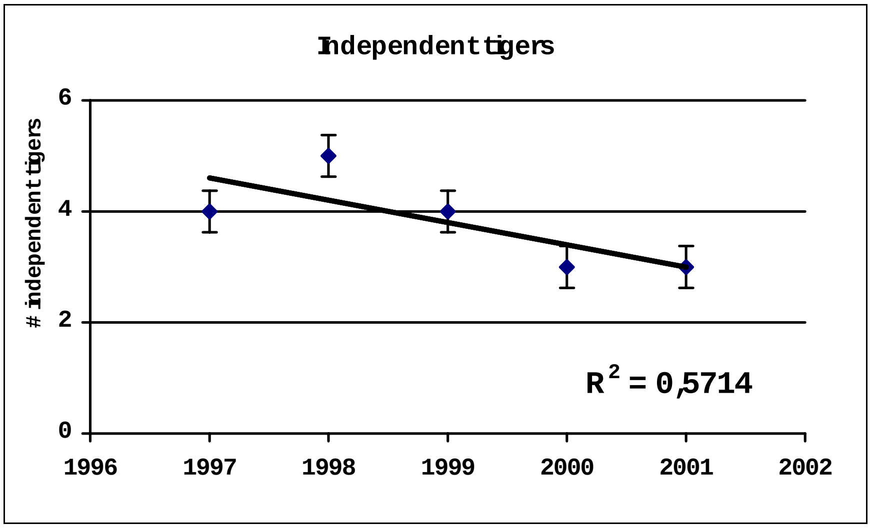
Tiger. During the 1st survey 8 tiger tracks (which belong to 3-5 individuals) were found on 185 km of survey routes (0.42 tracks per 10 km). During the 2nd survey also 8 tiger tracks were found on 240 km of survey routes (0.33 tracks per 10 km). Trophic conditions for tigers in Borisovskoe Plateau were satisfactory. In average predator can find more than 30 fresh tracks of ungulates per 10 km. Probably this is the reason why tigers were not "attached" to the areas with high concentration of ungulates. We can propose that even in extremely severe winters under such trophic conditions predators still stay on their usual territories, which they select earlier. In model unit such territories are: the middle and upper reaches of Vtoraya Rechka, upper basins of Sanduga, Borisovka, Malaya Elduga and Gryaznaya rivers and Skalistaya mountain. The disappearance of tiger tracks near Penyazhinsky deer farm in late winter and absence of tiger tracks in upper reaches of Bolshaya Elduga, where tracks were usually found in previous years could be of concern. It is possible that tiger tracks found in Skalistaya mountain area, upper reaches of Gryaznaya river and Penyazhinsky deer farm belong to one individual. The same situation is with tracks of female and young individual, which were found during both surveys in Vtoraya Rechka and Malaya Elduga river basins.

The lowest ungulates density was registered in Bolshaya and Malaya Kedrovka river basins. During the last 2-3 years tiger tracks were not found here as well. This fact makes it necessary to temporarily ban hunting ungulates in this territory. Taking into account that about 80-90% of young sika deer died of starvation it is rationally to prohibit or strictly limit hunting sika deer in forthcoming hunting season. It is also important to put a temporary ban on hunting roe deer.

Thus the following tigers were found in Borisovskoe Plateau model unit during the second half of winter 2002: one resident male (pad width 11.5 cm, his tracks were found in divide-cliff upper M. Elduga-M. Khokhoninsky creeks and upper basins of Sanduga and Borisovka rivers), one female (pad width 8.5-9 cm, her tracks were found in Vtoraya Rechka and M. Elduga) and one individual of unknown sex and age (pad width 9.0-9.2 cm, tracks were found in Amba, Gryaznaya rivers, Skalistaya mountain area and Penyazhinsky deer farm).


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
R^2 = 0,3333


Tiger track densities
tracks/day/100 km
2
1
0
1996
1997
1998
1999
2000
2001
2002
R^2 = 0,0078

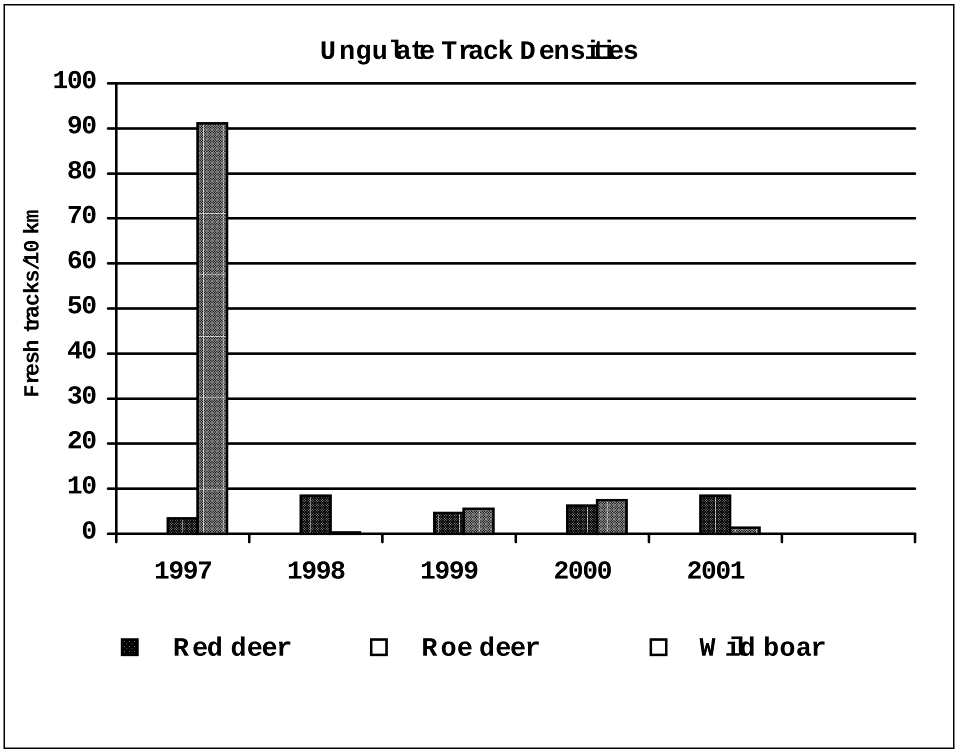


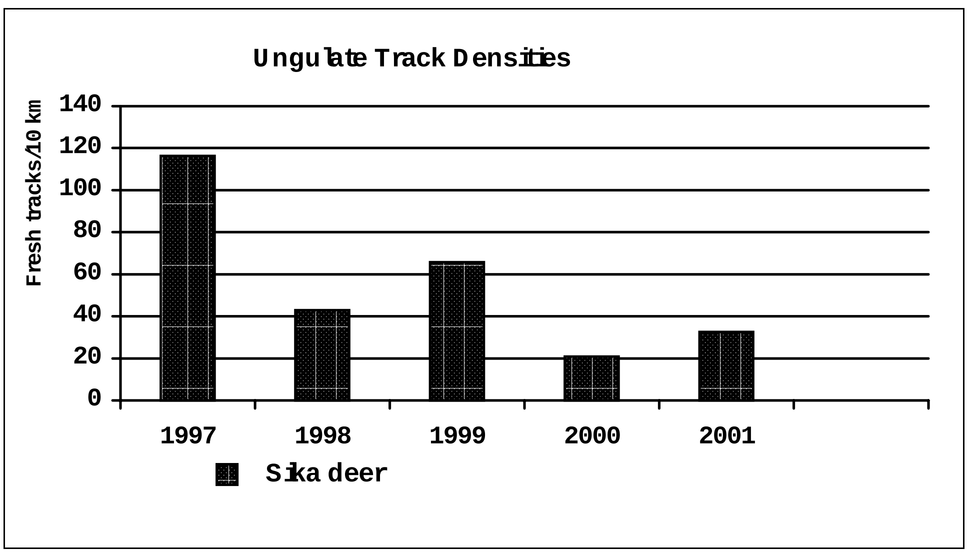
Number of tigers, by age class and sex (for adults only) in "Borisovskoe Plateau" Amur tiger monitoring site

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

Mean track density (tracks less than 24 hours) of ungulates in "Borisovskoe Plateau" Amur tiger monitoring site for 5 years

Year	n	Red deer		Roe deer		Sika deer		Wild boar	
		mean	SD	mean	SD	mean	SD	mean	SD
1997	14	0.02	0.10	3.38	7.97	116.29	206.68	91.09	193.32
1998	14	0.00	0.00	8.48	18.95	42.87	61.13	0.26	0.88
1999	14	0.00	0.00	4.58	8.37	65.74	113.10	5.53	8.13
2000	14	0.00	0.00	6.22	8.31	20.81	19.19	7.47	17.03
2001	14	0.00	0.00	8.42	18.32	32.51	66.53	1.38	4.54
Total mean		0.00	0.02	6.22	12.38	55.64	93.33	21.15	44.78


Ungulate Track Densities
Fresh tracks/10 km
100
90
80
70
60
50
40
30
20
10
0
1997
1998
1999
2000
2001
Red deer
Roe deer
Wild boar


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

SANDAGOY

Southeast Primorsky Krai

Report on results of Amur tiger monitoring program in Sandagou monitoring unit in winter 2001-2002
Coordinator - V.V. Aramilev, Institute for Sustainable Use of Natural Resources

This winter season snow distribution determined distribution and migration of animals within the territory and therefore strategy and tactics of monitoring efforts. Before January 7th snow fell two times - in early and late December. Both times snow cover was low and 2-3 days after southern slopes were free of snow. After snowfall on December 29-30 we plan to conduct the survey in a week after it, but snowfall on January 7-8 ruined this plan. After this snowfall snow depth was 69 cm. Snow depth was measured in Mysovka field station, which is situated in southern part of the model unit on the northern macroslope of Olginski ridge. In the northern part of model unit snow depth was slightly lower. First survey was conducted on January 19-20. We had to change the system of conducting counts because snow covered all forest roads. Only GAZ-66 vehicle could bring counters to their routes after the road was cleaned off snow. We had to send two counters to other routes to give them opportunity to cover the route in deep snow during one day. We had to change the location of our field group. To collect information about habitat changes we had to increase expenses for fuel and vehicle rent.

The next snowfall happened on January 20-21. It covered all tracks (average snow depth was about 23 cm). Then there was no snow until the second count, which was conducted on February 17-18.

Overall the situation with tiger prey species (ungulates) is improving. Increase of roe deer numbers was observed as well as sika deer numbers and range. High density of red deer still remains in mountainous areas. By November wild boar, whose density was high in the fall, migrated to Chuguevski Raion, where there was rich harvest of pinecones. Several herds of wild boars occurred only in creek valleys adjacent to Chuguevski Raion. We should mention that it is typical for wild boar to migrate from the territory of Olginski raion. When there is a rich harvest of acorns and pinecones numbers of wild boars increases in Olginski raion, if harvest is poor only individuals and small herds stay here.

Probably the migration of wild boars caused the migration of tigers from monitoring unit. During the first survey only two cubs in Mysovka fold and two tigers (probably male and female) traveling together in upper reaches of Berezovy creek were registered. According to on-line (operativnaya) information tigress (probably the mother of these two cubs) was poached.

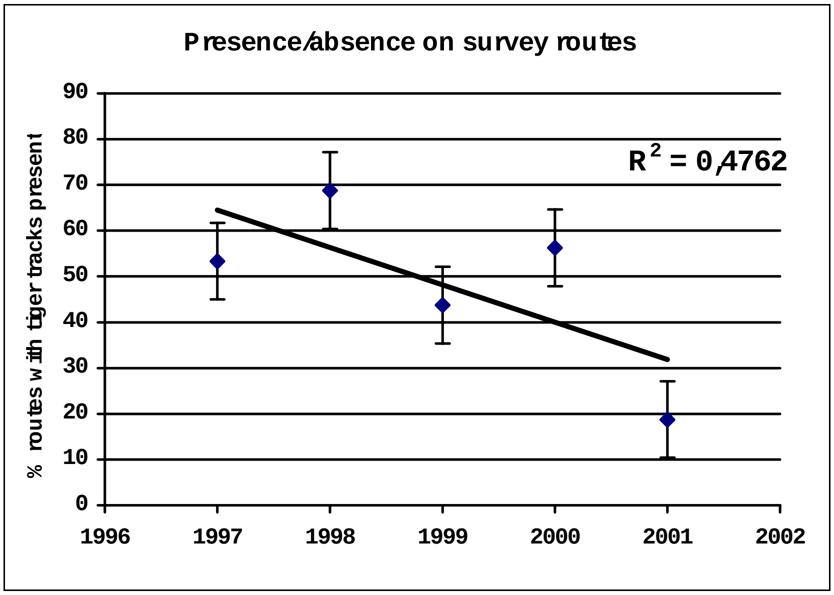
During the second survey in February only one tiger of unknown sex and age was registered. He was found in Mysovka field station area.

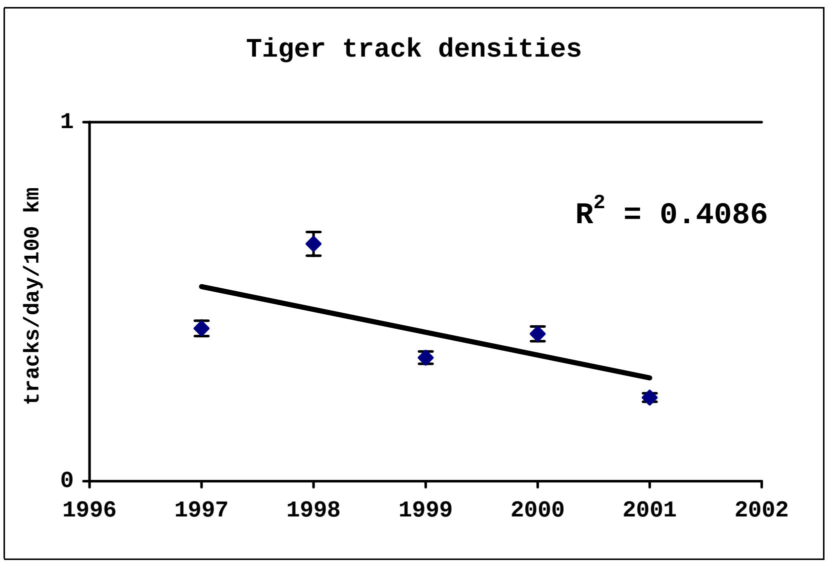
According to the information got from field station area tiger track (pad width 9.7 cm) was found in July, this tiger was not registered during winter counts (it may be the same tiger that was found in Berezovy creek area with pad width 10 cm). Also track of tiger cub with pad width 6.2 cm was found on the dust, then its tracks (7.3 cm) were found in shallow snow on frozen river.

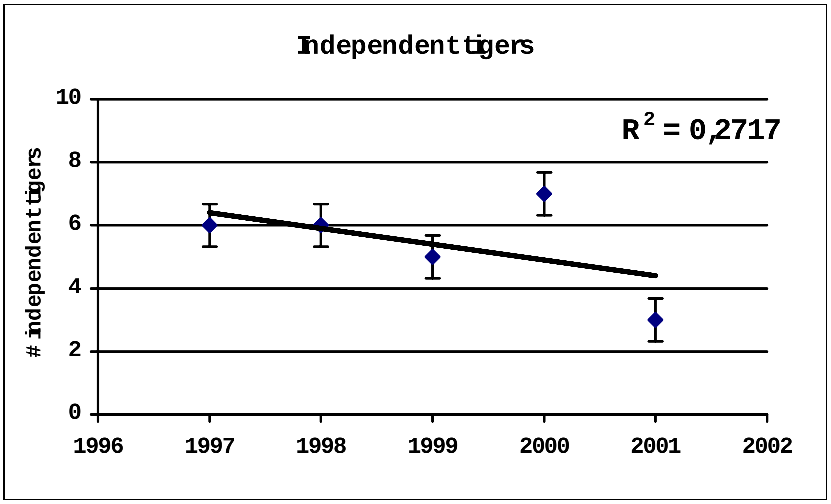
Tiger habitat in model unit did not change significantly. Logging still continues but this year (unlike previous years) it takes place on small wood-cutting areas throughout the model unit. One grass fire took place and one forest road (4 km long) was built to get timber out.

As usual poaching of ungulates by local militiamen and customs officers continues. Existing GosOkhotNadzor Service can not stop poaching by these people.

Results of next year monitoring will show us the beginning of what tendency we observe this season.


Presence/absence on survey routes
% routes with tiger tracks present
$R^2 = 0.4762$
0
10
20
30
40
50
60
70
80
90
1996
1997
1998
1999
2000
2001
2002


Tiger track densities
tracks/day/100 km
$R^2 = 0.4086$
0
1
1996
1997
1998
1999
2000
2001
2002

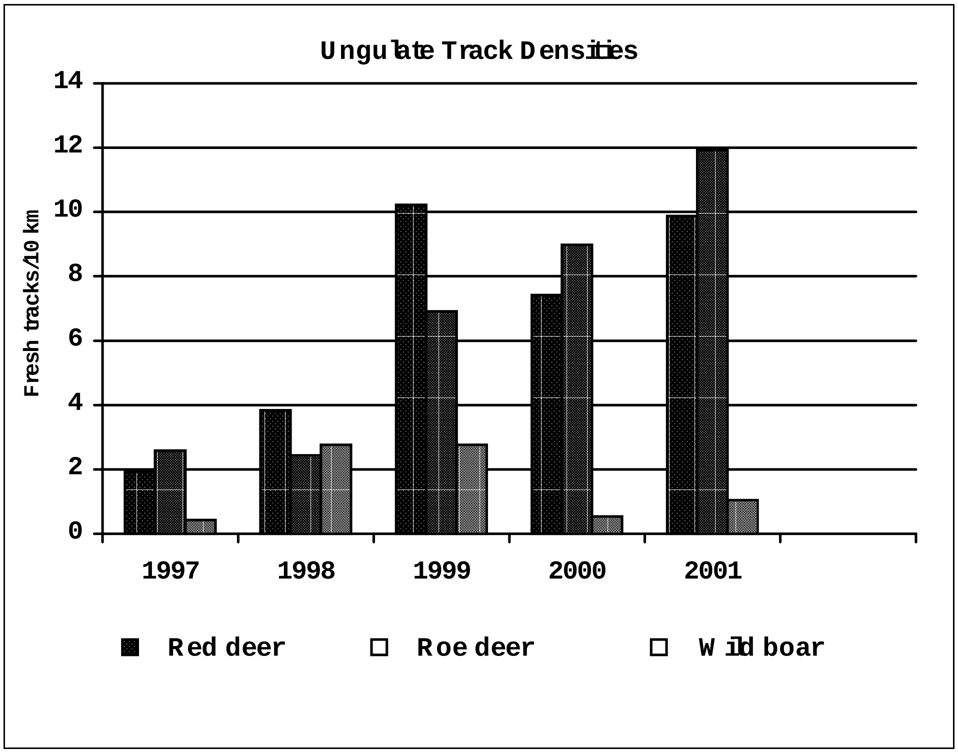


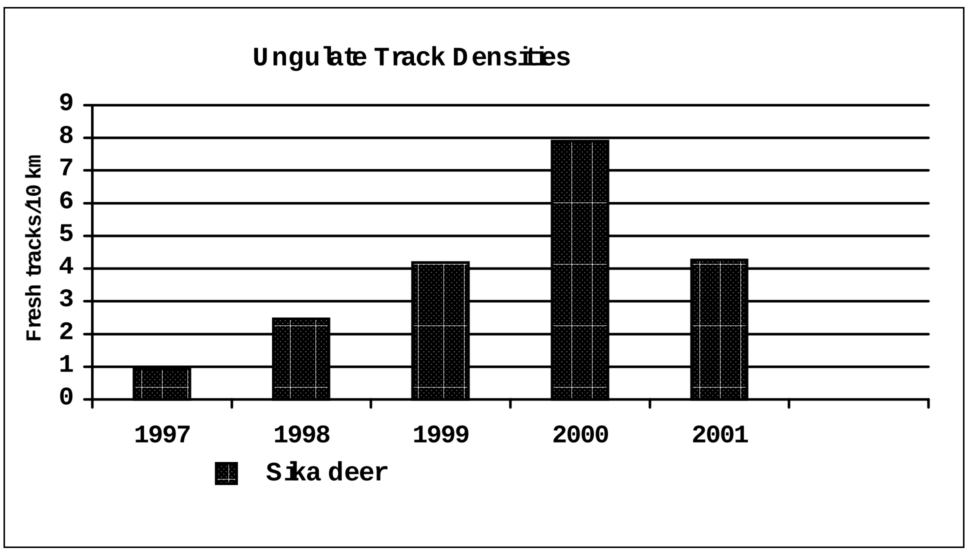
Number of tigers, by age class and sex (for adults only) in “Sandagou” Amur tiger monitoring site

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

Mean track density (tracks less than 24 hours) of ungulates in “Sandagou” Amur tiger monitoring site for 5 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	4.20	2.76	4.43
1999	16	10.22	12.10	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	9.80	4.27	7.04	1.04	4.05
Total mean		6.65	8.79	6.57	7.15	3.95	7.71	1.51	3.38


Ungulate Track Densities
Fresh tracks/10 km
14
12
10
8
6
4
2
0
1997
1998
1999
2000
2001
Red deer
Roe deer
Wild boar


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