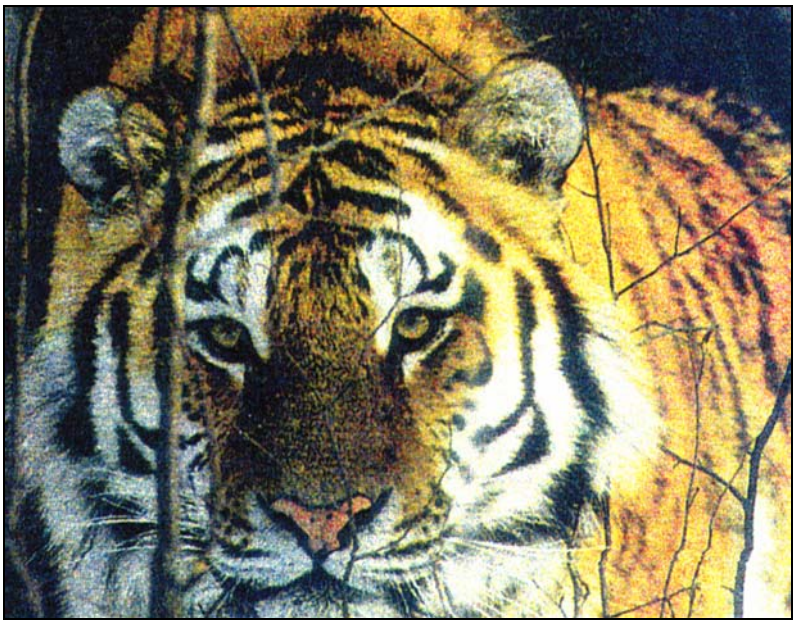
NUMBERS, DISTRIBUTION AND HABITAT STATUS OF THE AMUR TIGER IN THE RUSSIAN FAR EAST:

"Express-report"



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1. Introduction

Russia has primary responsibility for conservation of the Amur, or Siberian tiger (*Panthera tigris altaica*), one of the five remaining tiger subspecies. Of the original eight recognized subspecies, the Amur tiger is distinguishable by a number of morphological and ecological traits. At least 80-90% of the world-wide population of this animal resides in the Russian Far East. There are probably no more than 20 Amur tigers inhabiting adjacent regions of northeast China (Lu Binxin 1993), and there are only unconfirmed reports that Amur tigers remain on the Korean peninsula.

For the last one hundred years the Amur tiger population in Russia has fluctuated dramatically, from a relatively high number at the beginning of the century through a critical low in the late 1930's and early 1940's, when an estimated 20-30 animals remained in the Russian Far East (Kaplanov 1948). Although Kaplanov's estimate may be conservative, a population of probably no more than 50 (in the early 1940's) gradually increased up to the 1990's, and may have reached an estimated 300-400 individuals. According to the data obtained from the census conducted in the winter of 1984-1985, there were approximately 250 tigers found in the entire Russian Far East (Pikunov 1990), and a questionnaire survey indicated 338-350 tigers in 1990 in Primorye alone (Mescheryakov and Kucherenko 1990) (Table 1). The main factor responsible for the near extinction of this subspecies in the middle of this century was human persecution. The implementation of protective legislation in 1947 was a turning point for the tiger in Russia. Since that time conservation of this subspecies has become a key priority for regional and federal ecological policies. The latest confirmation of this fact is the Russian Federation's Resolution #795, "On the conservation of Amur tigers and other rare and endangered species of wild flora and fauna on the territory of Primorsky and Khabarovsky Krais," and the approval in July, 1996 by the Russian Federation Ministry of Environmental and Natural Resources Protection of a base document developed at a fine scale resolution, "Strategy for Amur Tiger Conservation in Russia".

Table 1. Distribution and number of Amur tigers in the Russian Far East reported in previous censuses

Year	Primorsky Krai	Khabarovsky Krai	Total	Source of information
1959	55-65	35	90-100	Abramov 1962
1965	70	-	-	Kudzin 1966
1970	129-131	20	149-151	Yudakov and Nikolaev 1973, Kazarinov 1979
1976	-	-	160-170	Bromley 1977, Kucherenko 1977
1979	172-195	34	206-229	Pikunov et al. 1983, Kazarinov 1979
1985	210-220	-	240-250	Pikunov 1990
1990	338-350	-	-	Mescheryakov and Kucherenko 1990

Although this species is not immediately threatened with extinction, its future has still been a cause for serious concern. With the exceptions of zapovedniks (reserves) and other protected areas, most forest lands within the range of tigers have been subjected to logging operations. Ungulate numbers have decreased everywhere, resulting in an obvious imbalance between populations of key prey species and the tiger itself. Most importantly, a dramatic increase in poaching has occurred since the beginning of the 1990's, which is largely a result of new

opportunities for selling tiger bones. Tiger products, believed to have powerful medicinal properties, are sold in the majority of East-Asian countries. As a result, it has been estimated that poaching has resulted in a 10% annual removal rate for the last five years (Pikunov 1994), equaling or perhaps exceeding reproductive potential of the population. The present situation is unlikely to change in the near future. Thus, monitoring the status of the population, and possible changes in tiger distribution, is vitally important.

Assessing the status of the Amur tiger population may be conducted in two possible ways: by sampling key count units, and then extrapolating to the entire population, or simultaneously censusing the entire range of tigers. Data collection on key sample units does not require as great a financial expense, and could be conducted at regular intervals. However, when conducting a census on rare and sparsely distributed species there is the potential risk of serious mistakes when extrapolating to large, unsampled regions. On the other hand, a detailed range assessment is a costly process that is difficult to organize, and is therefore, likely to be repeated only at infrequent intervals. However, a full survey of the existing range of the Amur tiger is the only way to get a complete picture of the present status of the population (with details on its present distribution), and an assessment of population dynamics. Most importantly, a full range survey provides a "snapshot" of the whole range of the tiger population, and its internal structure.

Two methods have been used over the last half century to assess the status of the tiger population in the Russian Far East, starting with the pioneering work of L. G. Kaplanov (1948): 1) special census efforts, with focus on key areas - such as in zapovedniks; and 2) censuses over large territories. Wide-ranging censuses of tigers in Primorsky and Khabarovsky Krais have been frequently conducted in the last 30 years, and over time the range of territory covered has increased, and data collection has been more standardized (Table 1). In comparison with similar work on tigers in South Asia, censuses in the Russian Far East have a great advantage in that they are conducted during winter when an almost continuous snow cover provides an excellent tracking media. For this reason, and the fact that track registration is mostly performed by professional hunters working on hunting units they are intimately familiar with, the estimates of tiger population size in Russia, including all the inevitable systematic errors, is still much more reliable than similar assessments in India or Sumatra (Sankhala 1979; Karanth 1987, 1993; Faust and Tilson 1994; Ramono and Santiapillai 1994).

The need for a tiger census over its entire range was stated in the resolution of the International symposium "Amur tiger - problems of population conservation" (Khabarovsk, March, 1993), in the "Amur Tiger Program", adopted by an international working group (Gaivoron, June 1994), and in the resolution of the international conference "Ecology and conservation of the Amur tiger" (Vladivostok, March 1995). In the Amur Tiger Program, it was emphasized that "accurate and current information about the condition of the Amur tiger population, and about threats to its habitat is fundamental for the evaluation of population viability and for the practical realization of conservation plan".

The objectives of the project "Numbers, distribution, and habitat status of the Amur tiger in the Russian Far East," were:

- to estimate the number of tigers, and to delineate characteristics of their distribution within existing range;
- to determine areas of minimum and maximum densities, to define areas at risk of fragmentation, and to assess the integrity of existing habitat;
- to characterize, as much as possible, the sex-age structure of the Amur tiger population and to determine its reproductive potential;
- to assess the present status (and long-term trends) of the Amur tiger population, and to develop recommendations for long-term conservation of the species in the Russian Far East.

E. N. Matyushkin was appointed head of the project (Moscow State University and The Commission on Large Predators, TO RAN), I. O. Suslov was responsible for overseeing the tiger census for the Primorsky Krai Administration (Vladivostok, Primorsky Krai Hunting Board), D. G. Pikunov was Primorsky Krai Coordinator (Vladivostok, Pacific Institute of Geography DVO RAN), and Y. M. Dunishenko was Khabarovsky Krai Coordinator (Khabarovsk, DVO VNIIOZ). Seven additional specialists with extensive experience in similar projects acted as regional coordinators: V. K. Abramov (Ussurisky Zapovednik), V. I. Bazylnikov (Primorsky Krai Hunting Board), V. G. Korkishko (Kedrovya Pad Zapovednik), I. G. Nikolaev (Institute of Biology and Soils, DVO RAN), G. P. Salkina (Lazovsky Zapovednik), E. N. Smirnov (Sikhote-Alin Zapovednik), and V. G. Yudin (Institute of Biology and Soils, DVO RAN).

D. G. Miquelle, biodiversity manager of the USAID Russian Far East Environmental Policy and Technology (EPT) Project, coordinated the project. Miquelle oversaw organization and collection of data, coordinated discussion of results with coordinators, and prepared data for input into a GIS database, which was developed by a group of specialists including W. T. Merrill (Co-operative Fish and Wildlife Research Unit, University of Idaho) and S. Krasnepeev (The Institute of Geography and Scientific Research Association of the Primorsky Regional Association of Indigenous Peoples), T. Bechtold (The Ecology Center, Missoula Montana), and V. Kulikov (The Wildlife Foundation of Khabarovsk).

Financial, logistical, and administrative support for "Tiger census-96" was provided by the USAID Russian Far East Environmental Policy and Technology Project. Additional financial assistance was provided by World Wide Fund for Nature (WWF-Germany).

2. Study area and conditions for the census

The entire territory inhabited by tigers in the Russian Far East that was incorporated into the census, stretches north to south for almost one thousand kilometers. This region is mainly represented by the Sikhote-Alin Mountain Range, which varies from 200-300 kilometers in width at different latitudes. Also included in the census was the edge of Eastern-Manchurian mountain system, which crosses into Russia from China at several places in southwest Primorye (Pogranichny, Khankaisky, Ussurisky, Nadezhdinsky, and Khasansky Raions), and where tigers were present in earlier censuses. The total area covered in 1995-96 winter census was 193,520 km^2; during the simultaneous count (see below) on February 10-12, 134,621 km^2 were covered. A synchronized census, employing one technique, over the entire range of the Amur tiger is unprecedented.

Practically the entire region censused is mountainous, as the Sikhote-Alin Mountains provide the majority of the remaining habitat for the Amur tiger. Generally, peaks are 500-800 meters above the sea level, with only a few reaching 1000 m or more. River basins are characterized by a "boxlike" profile, with flat river bottoms ranging in width from several tens of meters up to a kilometer and more. Mountain ridges are straight and can extend without dramatic changes in height for considerable distances, while slopes are moderately to very steep. Ridges rise above rivers and creeks 300-500 m, but 250-300 m is more typical. Large cliffs are not numerous and distributed sporadically, although small rocky outcrops and isolated cliffs are usually located on steep river slopes, especially on narrow spurs stretching down to the basins.

The territory included in the census is completely forest covered. Typical tiger habitats are valley and mountain "cedar," Korean pine (*Pinus koraiensis*) -broad-leaved forests with a complex composition and structure. The large majority of these forests have been selectively logged at various times in the past. The past history of logging and fire has resulted in much of the region being comprised of secondary broad-leaved forests, especially oak (*Quercus* spp.) and

birch (*Betula* spp.) stands. A broad zone of oak and other secondary forests have formed along the periphery of Sikhote-Alin and at the lower elevations, including lands managed for agricultural production. Above 700-800 m, spruce (*Picea* spp.)-fir (*Abies* spp.) forests prevail in central Sikhote-Alin. This elevational boundary for the predominantly coniferous forest type increases to the south, and decreases northward, until, at 47'20'' latitude, coniferous forests occur along the coastline.

The main forms of economic activity in the Sikhote-Alin ecosystem are logging and hunting. There are also regions with intensive mining activity, primarily in the remote parts of Sikhote-Alin. Wide-ranging agricultural activity occurs on the periphery of the Sikhote-Alin Mountains, and in the interior along the wide river basins. Settlements are scattered throughout tiger range, but the associated road network is dense in some places, especially where intensive logging has occurred.

The most important tiger habitat - primary and secondary Korean pine-broad-leaved forests - occupy the central position in the sequence of landscape changes associated with elevational changes. These forest types are squeezed between a strip of almost unbroken agricultural lands along the periphery of Sikhote-Alin, and the coniferous forests at higher elevations in the interior. Accordingly, in the northern limits of tiger range, suitable habitat extends in the form of two "peninsulas", one on the interior, western macroslope of the Sikhote-Alin Mountains, the second along the coastline (Figure 2).

This general knowledge of tiger habitat formed the basis for developing a census network: count units in each region began at the edge of agricultural lands and continued into the upper reaches of basins, excluding large tracts of spruce-fir "taiga", although in some northern basins (e.g., the Samarga and Botchi), large expenses of spruce-fir were included in the census area. Along the Sikhote-Alin periphery, where habitat fragmentation and human impact is more common, the area of individual count units was substantially smaller than those in remote taiga regions (Figure 1). Most count units covered a section of a basin or small river for 10-30 kilometers. Survey routes within count units were determined on the basis of natural, topographic and hydrological features. Survey routes were selected to increase the probability of encountering tiger tracks: tiger movements are characterized by a generally well-defined pattern in relation to topographic and hydrological features (riverbeds, terraces, base of slopes, mountain ridges) that serve as orientation points (Matyushkin 1977). Routes most preferred by tigers, especially in deep snow, are forest roads and snowmobile trails.

In winter, nearly the entire range of Amur tigers is usually snow-covered. However, there may be considerable differences in height and state of snow cover between regions. In the 1995-1996 winter snow cover was complete in most of the region by December. By the time of the simultaneous census (see below), snow depth ranged from 40 to 60 cm in valleys on the western macroslope of middle Sikhote-Alin, and 15-25 cm in the southeastern Sikhote-Alin (e.g. Lazovsky Zapovednik), although a narrow strip of coastline remained partially free of snow. During and immediately preceding the simultaneous census, there was no snowfall sufficient to cover tiger tracks in any region of the census. In general, snow conditions were favorable for the census work, except in southwestern Primorye, where complete, lasting snow cover never occurred.

3. Methods

The Amur tiger census was conducted in the winter of 1995-1996 on all potential habitat, as delineated from previous censuses in the Sikhote-Alin Range (Primorsky and Khabarovsky Krais) and in the spurs of the eastern Manchurian Mountains (southwest Primorsky Krai). The entire territory was split into 8 regions based on administrative boundaries of Raions (districts or

counties) - one "raion group" in Khabarovsky Krai and seven in Primorye (Table 2). One specialist was designated coordinator for each raion group. This division of the study area greatly facilitated organization and analysis of material, and provided a basis for analysis of geographical differences in characteristics of the tiger population (e.g., density, reproduction), conditions of tiger habitat, and for developing conservation recommendations.

Coordinators were responsible for the following raions:

Primorsky Krai:

Pikunov : Pozharsky, Krasnoarmeisky (excluding the Armu Basin), Pogranichny, Ussuriysky (the western half), Nadezhdinsky (basins west of the Razdolnaya River), Khasansky (the northern part, inclusive of the Amba Basin);
Nikolaev: Dalnerechensky, Kirovsky, Lesozavodsky, Yakovlevsky;
Yudin: Spassky, Chernigovsky;
Abramov: Anuchinsky, Mikhailovsky, Ussurisky (eastern part), Shkotovsky, and vicinity of Vladivostok;
Salkina: Chuguevsky, Lazovsky, Partizansky;
Bazylnikov: Kavalerovsky, Olginsky;
Smirnov: Terneisky, Krasnoarmeisky (the Armu basin), Dalnegorsky;
Korkishko: Khasansky.

Khabarovsky Krai:

Dunishenko: Bikinsky, Vyazemsky, Lazo, Komsomolsky, Nanaisky, Sovgavansky, Khabarovsky.

The study area was split into 652 count units (516 in Primorsky Krai, 136 in Khabarovsky Krai) (Figure 1). Within each count unit designated fieldworkers were responsible for recording data on presence/absence of tigers, measuring track size, directional movement of tigers, date of occurrence, and providing first estimates of sex and age.

Coordinators and regional hunting specialists selected fieldworkers based on their experience in count units, and their specific knowledge about tiger habitat and movement patterns of tigers within individual count units. The majority of fieldworkers were either professional hunters, zapovednik forest technicians, or rangers working at zakazniks (wildlife refuges), trade hunting or sport hunting units: thus, most fieldworkers had already worked within a count unit for many years. In total, 655 fieldworkers were involved in the census.

The area of count units ranged in size from 20,000 to 60,000 ha, depending on the estimated number of tigers within a general region, the pattern of tiger distribution, forest types, forest fragmentation, density of wild ungulates, density of roads, and snow conditions. As a result, the potential for fully covering count units varied.

A field "diary" was provided for each count unit and each coordinator or regional specialist provided instructions for each fieldworker, who at the same time signed a contract to conduct the work. The field diary contained detailed instructions on procedures and data sheets for collecting and reporting data of the following types: all occurrences of tiger tracks, track size, perceived changes in number of tigers compared to previous years, any information on tiger deaths over the last 10 years, information on past and present occurrences of tigresses with cubs on the count unit, ungulate numbers (based on track counts, and the field counters assessment of numbers), occurrences of kills made by tigers on wild prey, and occurrences of tiger depredation on domestic animals. Additionally, several questions were asked to assess the attitude of fieldworkers towards tigers. Information on tigers was collected in field diaries as two separate count periods:

1. All-winter track count: from November (beginning with the first snow fall) to February, and, in some cases, until March;
2. Simultaneous census: conducted during February 10-12, 1996. The timing for the simultaneous census was selected to coincide with simultaneous counts of earlier censuses (in 1979 and 1985). Census routes during the simultaneous census were no less than 25 km in each count unit, and were delineated to include all places within the count unit where tiger tracks had been encountered in the previous months.

Table 2. Division of tiger habitat into raion groups

Krai	Group Raion	Raion
Primorye	Southwest	Khasanky
		Nadezhdensky
		Ussurisky (west)
Primorye	Western	Pogranichny
Primorye	Southern	Spassky
		Chernigovky
		Mikailovsky
		Chuguevsky
		Anuchinsky
		Ussurisky (east)
		Vladivostok outskirts
		Shkotovsky
Primorye	Southeast	Kavelerovsky
		Olginsky
		Partizansky
		Lazovsky
Primorye	Northeast	Terneisky
		Dalnergorsky
Primorye	Northwest	Pajarsky
		Krasnoarmeisky
		Dalnerechensky
		Lesozavodsky
		Kirovsky
		Yakovlevsky
Khabarovsk	North	Bikinsky
		Vyazemsky
		in-the-name-of Lazo
		Komsomolsky
		Nanaisky
		Sovgansky
		Khabarovsky

Tiger tracks on count units were recorded both on diary data sheets and maps (scale 1:100,000) with a unique track number, estimated date of passage by the animal, width of the pad on the front paw, estimate of sex, and presence of cubs (and their pad width). The all-winter count and the simultaneous census were reported separately.

Regional coordinators organized and summarized data from fieldworker diaries in the following manner:

- a summary map (scale 1:100,000) was prepared for all tiger tracks encountered during the simultaneous census of February 10-12;
- an analogous map was developed for tracks reported from the all-winter data set;
- based on these maps, identification of individuals was based on: a comparison of track sizes and individual characteristics; probable or exact information on date a track was created; existing data on potential 24-hour travel distances of different sex and age classes, determined from winter tracking (Yudakov and Nikolaev 1987), and values of average linear daily travel distances and diameter of home ranges, according to the results of radio-tracking (Miquelle and Smirnov unpublished). For mapping general locations of individuals, a larger scale map (1:500,000) was used.

To better organize original material for estimating tiger numbers, the simultaneous and the all-winter counts were compiled separately, and the all-winter database was additionally separated into two periods: November-December and January-March. These 3 data sets were analyzed in the following order: simultaneous census, all-winter track registration in January-March, and finally, all-winter track registration from November-December.

All individual tigers delineated on the basis of track criteria were divided into 2 reliability classes: positive and questionable delineation (when delineation criteria were at their maximum values or when there was unreliable information in the field data, it was unclear whether some sets of tracks represented new animals). Use of the criteria was not always rigid. On occasion an evaluation of the available information was based on the field experience of the coordinator. Identification of individuals was especially problematic at boundaries of raion groups, where there was a risk of double counting tigers that used both sides. To avoid the potential for overcounting, all the original data along boundaries were analyzed jointly by coordinators of adjacent raions.

In summarizing results, two rigid sets of criteria for identification of individuals were developed based on the track registration data: “soft” (criteria boundaries were smaller, resulting in larger count estimates) and “hard” (criteria boundaries were larger, resulting in smaller count estimates). These criteria provided a control that effectively limited subjective decisions on identifying individuals. Use of these criteria gave assuring results. However, in consideration of the fact that original material was quite heterogeneous, we chose to confine ourselves to the traditional data processing method, and to conduct a detailed analysis in the future.

The area of suitable tiger habitat was calculated by each coordinator for his/her census region using existing material. The following land formations were not included as tiger habitat: settlements, non-forested sections, swamps, high elevation alpine communities, spruce-fir forests or burns on former spruce-fir forests, and areas with excessively deep snow cover in winter (above 100 cm) which effectively excludes tigers.

The area inhabited by tigers was calculated by summing the area of count units where tiger tracks were encountered during the all-winter or simultaneous census. The relative density of tiger tracks per 10 km along census routes (Fig. 3 and 4) and individuals per 1000 km^2 of suitable habitat in administrative raions was determined (Fig. 6, Table 4). Relative track density provides an estimate of tiger distribution without relying on an estimate of tigers numbers.

Data from the all-winter count and simultaneous census were summed by administrative raions (Tables 3 and 4), by raion groups, and for Primorsky and Khabarovsky Krais (Table 5).

Determination of track distribution along the periphery of tiger territory provided the basis for delineating distribution boundaries of Amur tigers in the winter of 1995-1996 (Figures 2 and 3).

Delineating the sex-age structure of the tiger population was based on measurements of track size. There is a considerable database for estimating sex of tigers from track sizes, based on measurements of the width of main pad of the front paw of known sex and age tigers. Besides information from zoos (Matyushkin and Yudakov 1974), there are data on tigers in the wild that died or were killed in nature (Nikolaev and Yudin 1993), and also on animals captured and radiocollared (Miquelle and Smirnov unpublished). Thanks to help of Ms. S. Christie, EEP Tiger Coordinator, this year we obtained additional track size data from captive tigers. Data from 130 tigers of determined sex and age confirm previous assessments (Matyushkin and Yudakov, 1974). We summarize the main points here.

With very few exceptions, tracks with pad width equal or exceeding 10.5 cm represent males. Tracks ranging in size from 8 to 10.5 cm include both adult (and subadult) tigresses and subadult males, although females are the predominant sex in this category. Many zoo-raised males exceed 10.5 cm in their second year; similar measurements have been made on young males still traveling in a family group in the wild (Miquelle and Smirnov unpubl.). In general, pad size stabilizes when males reach 3-4 years of age. Identification of tigresses is reliable when smaller tracks (representing cubs) are found in association with them, and in these cases, all measurements of tigress pad width are within the 8 to 10 cm range. Track measurements of cubs in association with mothers in winter usually range in size from 6.5 to 8 cm, but as already noted, can reach 10.5 cm.

Because of the difficulties in differentiating sex of animals by track size, a considerable percentage of animals are recorded as unknown sex (Table 6). Accordingly, assessment of the sex ratio of the Amur tiger population from available census data should be made cautiously.

Litter size dynamics were analyzed using material from both the present census and reports of field workers who recorded presence of litters on their count unit between 1989-1996. With this data we attempted to assess changes in litter size associated with geographic variation, yearly variation, and variation over the winter.

All fieldworkers were requested to report information on tiger deaths in their field diaries. Additional information was acquired verbally by questioning field counters, employees of state hunting management services and local villagers. These data were used to compare the extent of poaching activity for the periods 1985 to 1990 and 1991 to 1996, when available evidence suggested a surge in poaching due to new opportunities to sell tiger products.

Tiger population density (Figure 6) and location of identified individuals throughout Primorsky and Khabarovsky Krais (Figure 5) were first mapped by each specialist for his/her region, and subsequently generalized by krai coordinators. Tiger distribution maps (Figures 5 and 6) include the number of positively identified individuals only.

The summary map of tiger distribution in the Russian Far-East (Figure 5) represents the collective effort of all coordinators, who relied on the reports of fieldworkers, but also used their knowledge of the region and their experience gained during research on Amur tigers. The technique of data collection and analysis used in the present census was generally similar to those used in previously censuses (particularly, the last three censuses). Similarity in methodology allows us to compare results, and assess long-term trends in the dynamics of the Amur tiger population.

4. Results

4.1 Number and distribution of tigers in the Russian Far East

Primorsky Krai

Results of the census confirmed that in addition to the main population of tigers in the Sikhote-Alin Mountain Range, tigers occur in two small, isolated habitat fragments near the Chinese border in the West and Southwest regions of Primorsky Krai (Figures 2 and 5).

Western Raion Group. This fragment of habitat includes parts of Pogranichny and Khankaisky Raions in Primorsky Krai. Suitable tiger habitat comprises less than 240,000-250,000 ha. It is divided from the Sikhote-Alin population by extensive non-forested Prikhankaiskaya lowlands; and from the Southwestern habitat fragment by non-forested and agricultural lands of the Razdolnaya River Basin.

Tigers have been rare in this habitat fragment for at least 30-40 years. No more than 4 individuals were found in this area in 1970 (Yudakov and Nikolaev 1973), no tigers tracks were found in 1978-1979 (Pikunov et al. 1983) and tigers were apparently absent almost to the end of the 1980's. Tigers reappeared again at the beginning of the 1990's, but there was likely never more than 4-6 individuals. High and stable number of ungulates, especially of wild boar, has not resulted in an increase of this "micropopulation" probably due to intensive tiger poaching, typical for such hunting units where intensive sport hunting of ungulates occurs.

The range of all tigers using this region no doubt extends into China despite the existence of a fenced boundary along the Russian Border Protection Zone. Tiger poaching is likely occurring in China as well as Russia.

It has been speculated that this Western population of tigers may retain contact with the Southwestern population through the territory of Heilongjiang Province, China. However, contact seems unlikely due to a high human population in this territory and the absence of suitable tiger habitat.

Apparently, tigers periodically disperse in the Western habitat fragment by passing through the Prikhankaiskaya lowlands (such occurrences have been reported), or via Ussuriysky and Oktyabrsky Raions of Primorsky Krai by following the country border. The second route seems more likely. Considering the complexities of current natural resource utilization policies, and the current state of environmental protection organizations, the likelihood of an increase in the number of tigers in the western habitat fragment is low.

For the entire winter period of 1995-1996, tiger tracks were located near the Chinese border in the upper basin of the Right Komissarovka River. Two adult individuals appeared here at different times: a male tiger with pad width of 10.5 cm, and a female (9.0 cm) with two cubs (8.5 and 8.0 cm.) that wandered independently. All four individuals periodically crossed the country border into China.

Southwestern Raion Group. The area of suitable tiger habitat in this region is 350-400,000 ha. Movement of individuals between this region and Sikhote-Alin are likely to occur through the area between Teryokhovka and Baranovsky villages, where spurs of the Sikhote-Alin Mountains closely approach the eastern edge of Borisovskoe Plateau. The number of tigers in this region has varied from 2 -3 individuals in 1970 to 14 in 1985, including individuals that range back and forth between China and Russia. In the southern part of this region a narrow band of habitat, surrounded by non-forested lands and the coastline of the Sea of Japan, forces most tigers to range on both sides of the international border. The upper reaches of river basins

Figure 1. Distribution of count units, and tiger tracks within those units, in Primorye and Khabarovsk Krai, Russian Far East, winter 1995-1996

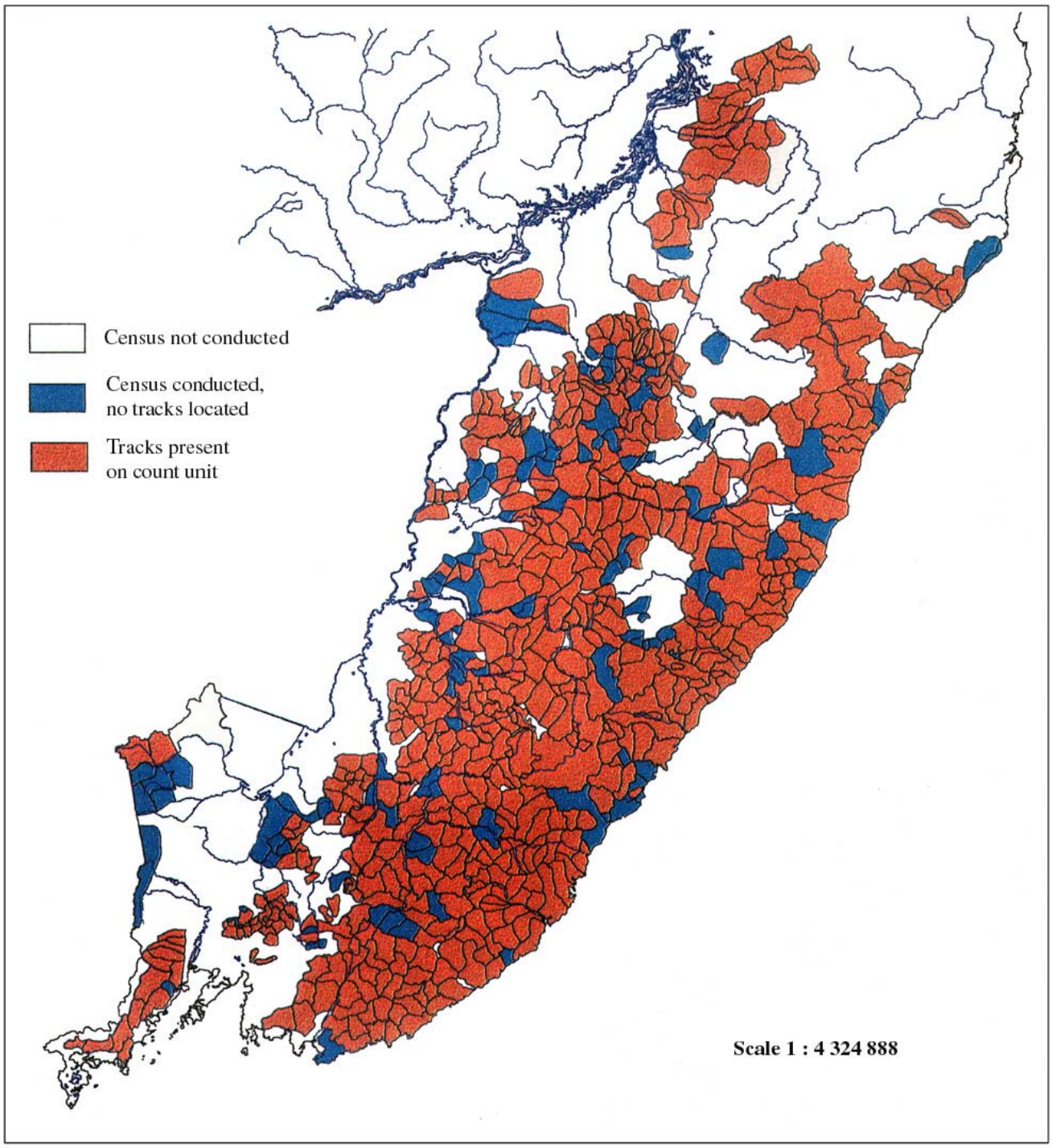


Figure 2. Distribution of tiger tracks from the simultaneous and all-winter counts (Primorye and Khabarovsk Krais, winter 1995-1996)

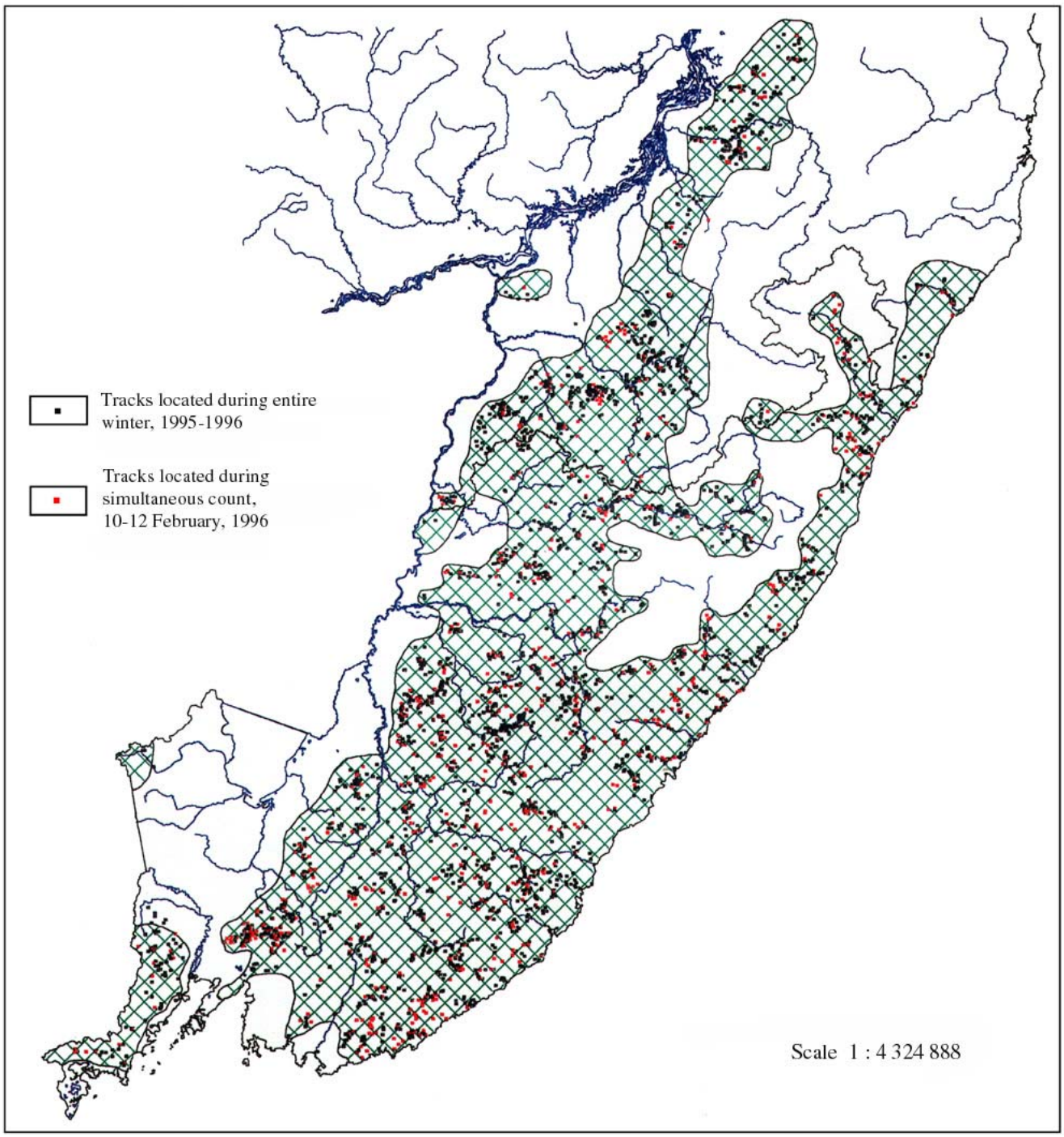


Table 3. Summary of tiger tracks reported in each raion of Khabarovsky and Primorsky Krais

Krai	Coordinator	Raion	Total count units	Number of tracks			
				Nov - Dec 1995	Jan - Feb - Mar 1996	Simultaneous count 1996	Total
Primorsky	Abramov	Anuchinsky	15	21	16	15	52
	Abramov	Vladivostok outskirts	1	0	1	0	1
	Abramov	Mikhailovsky	5	15	6	9	30
	Abramov	Ussurisky (east)	10	12	17	27	56
	Abramov	Shkotovsky	8	20	34	18	72
	Bazylnikov	Kavalerovsky	20	58	43	35	136
	Bazylnikov	Olginsky	27	67	61	41	169
	Korkishko	Khasansky	8	9	16	11	36
	Nikolaev	Dalnerechensky	40	109	64	34	207
	Nikolaev	Kirovsky	12	30	9	35	74
	Nikolaev	Lesozavodsky	6	31	1	8	40
	Nikolaev	Yakovlevsky	11	20	9	9	38
	Pikunov	Krasnoarmeisky	32	84	48	32	164
	Pikunov	Nadezhdinsky	6	8	11	0	19
	Pikunov	Pogranichny	7	2	2	0	4
	Pikunov	Pozharsky	68	147	93	49	289
	Pikunov	Ussurisky (west)	5	7	14	5	26
	Pikunov	Khasansky		0	0	3	3
	Salkina	Lazovsky	21	46	29	63	138
	Salkina	Partizansky	19	41	18	21	80
	Salkina	Chuguevsky	50	96	69	60	225
	Smirnov	Dalnegorsky	7	15	3	11	29
	Smirnov	Krasnoarmeisky	30	39	51	23	113
	Smirnov	Terneisky	85	217	106	116	439
	Yudin	Spassky	12	17	19	7	43
	Yudin	Chernigovsky	11	11	6	8	25
Khabarovski	Dunishenko	Bikinsky	6	17	9	4	30
	Dunishenko	Vyazemsky	17	66	49	16	131
	Dunishenko	in-the-name-of Lazo	73	175	156	45	376
	Dunishenko	Komsomolsky	5	17	3	5	25
	Dunishenko	Nanaisky	25	87	34	23	144
	Dunishenko	Sovgavansky	9	5	23	8	36
	Dunishenko	Khabarovsky	1	6	0	1	7
Total			**652**	**1495**	**1020**	**742**	**3257**

and the whole western part of the region is presently the best available habitat because it is protected by the border patrol guards. Due the strategic location and special status, these regions contain well-protected black fir-Korean pine-broad-leaved forests, high and stable numbers of

wild ungulates, a low density road network, and in general a low level of disturbance. The best potential for protecting tiger habitat occurs on the Borisovskoe Plateau Zakaznik, Barsovy Zakaznik and Kedrovaya Pad Zapovednik. Presently, the ungulates of this region are under intensive hunting pressure from the residents of Vladivostok and Ussuriisk. Suppression of tiger numbers is most likely due to poaching and official shooting of tigers causing depredation problems at deer farms. A minimum of 5 individuals were counted within Khasansky Raion in the winter of 1995-1996: 2 males, 1 tigress with a cub and 1 individual of undetermined sex. Tracks of the latter were registered from the Barabashevka middle drainage to the Amba and Gryaznaya Rivers by two adjacent coordinators. One male tiger was reported in Nadezhdinsky Raion, tracks most often appearing in the Gornaya Basin and on the right bank of the Borisovka River. It is quite possible that this male, as well as the two inhabiting southern Khasansky Raion, travel between Russia and China. The presence of a single individual of undetermined sex was observed in the western half of Ussuriysky Raion (in the Krounovka Basin).

In summary, the maximum number of individuals identified in the Southwestern Raion Group was: 3 adult males, 3 females (one of which had one cub), and 2 individuals of undetermined sex, for a total of 8 individuals (7 adults and 1 young).

The rest of the raion groups included in the winter census of 1995-1996 are situated within the Sikhote-Alin Mountain Range. Each of these regions is examined separately.

Northwestern Raion Group. This region includes the western Sikhote-Alin macroslope in the northern and central regions of Primorsky Krai. This isolated and sparsely populated territory retains relatively intact Korean pine-broad-leaved forests, and for the last 25 years has been considered one of the best remaining blocks of tiger habitat. In the past, 20-30% of the Sikhote-Alin tiger population inhabited this region.

In the 1970 census, the maximum number of tigers was reported in the Malinovka (Vaku) and middle Big Ussurka (Iman) Basins. As intensive development of this region proceeded, the core region of this population shifted to the north and was concentrated in the Bikin River Basin in the 1980's and 90's. The results of the 1979 and 1985 censuses indicated that the density of tigers in this region was exceeded only by Sikhote-Alin and Lazovsky Zapovedniks. Results of the present census also demonstrated that the middle and upper portions of the Malinovka Basins retain a very high number of tigers, similar to that found in the 1970's.

This raion group occupies 59,355 km^2, but suitable tiger habitat occurs only on approximately 80% of the region (48,268 km^2) (Table 5). Besides non-forested lands, high elevation spruce-fir, small-leaved deciduous, and larch forests near the crest of the Sikhote-Alin Mountains hold deep snows that effectively limits use by tigers in winter.

Suitable tiger habitat in the raion group was divided into 199 count units (averaging 26,700 ha) that were the basis for gathering information on tigers in the region. Permanent snow cover was complete by the beginning of November, and by the time of the simultaneous census (February 10-12), snow depths had reached 30-40 cm or more throughout most of the territory.

On the one hand, heavy snow made the census easier because in deep snow tigers prefer to move on frozen rivers and creeks, roads, sled trails and paths where travel is easier. On the other hand, chances of not counting individuals that remain for long periods within a small territory increase. However, the risk of a poor count is not that high in this raion group, as most fieldworkers were local residents with extensive experience working in the taiga.

Table 4. Summary of tiger census by raions, with estimate of suitable tiger habitat, and density estimate

Krai	Raion Group	Raion	Suitable tiger habitat km^2	Number of animals positively identified		questionably identified		Minimum number of adults	Maximum number of adults	Maximum density of adults/ 1000 km^2
				adults	cubs	adults	cubs			
Primorsky	Southwestern	Khasansky	3500	4	1	1	0	4	5	1.4
		Nadezhdinsky	700	0	0	1	0	0	1	1.4
		Ussurisky (west)	800	2	0	0	0	2	2	2.5
	Western	Pogranichny	2500	0	0	2	2	0	2	0.8
	Southern	Vladivostok outskirts	170	0	0	2	0	0	2	11.8
		Anuchinsky	2650	9	2	0	0	9	9	3.4
		Mikhailovsky	945	3	2	0	0	3	3	3.2
		Ussurisky (east)	875	5	1	1	0	5	6	6.9
		Shkotovsky	1650	7	1	1	0	7	8	4.8
		Chernigovsky	591	2	0	2	0	2	4	6.8
		Spassky	1371	6	0	1	0	6	7	5.1
		Chuguevsky	11600	27	5	2	0	27	29	2.5
	Southeastern	Kavalerovsky	4200	15	3	1	0	15	16	3.8
		Olginsky	6320	17	3	1	0	17	18	2.8
		Lazovsky	4583	22	11	0	0	22	22	4.8
		Partizansky	4211	8	1	0	0	8	8	1.9
	Northeastern	Dalnegorsky	3000	5	6	1	1	5	6	2.0
		Terneisky	25000	62	13	7	3	62	69	2.8
	Northwestern	Krasnoarmeisky	19825	28	8	3	5	28	31	1.6
		Pozharsky	17663	25	3	6	7	25	31	1.8
		Dalnerechensky	5970	20	6	2	0	20	22	3.7
		Kirovsky	1865	7	0	1	0	7	8	4.3
		Lesozavodsky	1295	2	0	0	0	2	2	1.5
		Yakovlevsky	1650	6	3	1	0	6	7	4.2
Khabarovsky	Northern	Bikinsky	1429	2	1	1	0	2	3	2.1
		Vyazemsky	2734	8	1	1	0	8	9	3.3
		in-the-name-of Lazo	15082	19	6	2	2	19	21	1.4
		Khabarovsky	782	2	2	0	0	2	2	2.6
		Nanaisky	8208	12	5	1	0	12	13	1.6
		Komsomolsky	1676	1	1	0	0	1	1	0.6
		Sovgavansky	3726	4	0	0	0	4	4	1.1
Total area			**156571**	**330**	**85**	**41**	**20**	**330**	**371**	**2.4**

Table 5. Summary of 1996 Amur tiger census by raion groups.

Krai	Raion group	Suitable tiger habitat, km^2	Registered animals positively identified		questionably identified		Minimum number of adults	Maximum number of adults	Minimum total population	Maximum total population	Maximum adult tiger density (/1000 km^2)
			adults	cubs	adults	cubs					
Primorsky	Northeastern	28000	67	19	8	4	67	75	86	98	2.7
Primorsky	Northwestern	48268	88	20	13	12	88	101	108	133	2.1
Primorsky	Southern	19852	59	11	9	0	59	68	70	79	3.4
Primorsky	Southeastern	19314	62	18	2	0	62	64	80	82	3.3
Primorsky	Southwestern	5000	6	1	2	0	6	8	7	9	1.6
Primorsky	Western	2500	0	0	2	2	0	2	0	4	0.8
Total in Primorsky Krai		122934	282	69	36	18	282	318	351	405	2.6
Total in Khabarovsky Krai		33637	48	16	5	2	48	53	64	71	1.6
Total		**156571**	**330**	**85**	**41**	**20**	**330**	**371**	**415**	**476**	**2.4**

Figure 3. Density of Amur tiger tracks on count units in Primorye and Khabarovsk Krais, based on data collected from the simultaneous count (February 10-12, 1996)

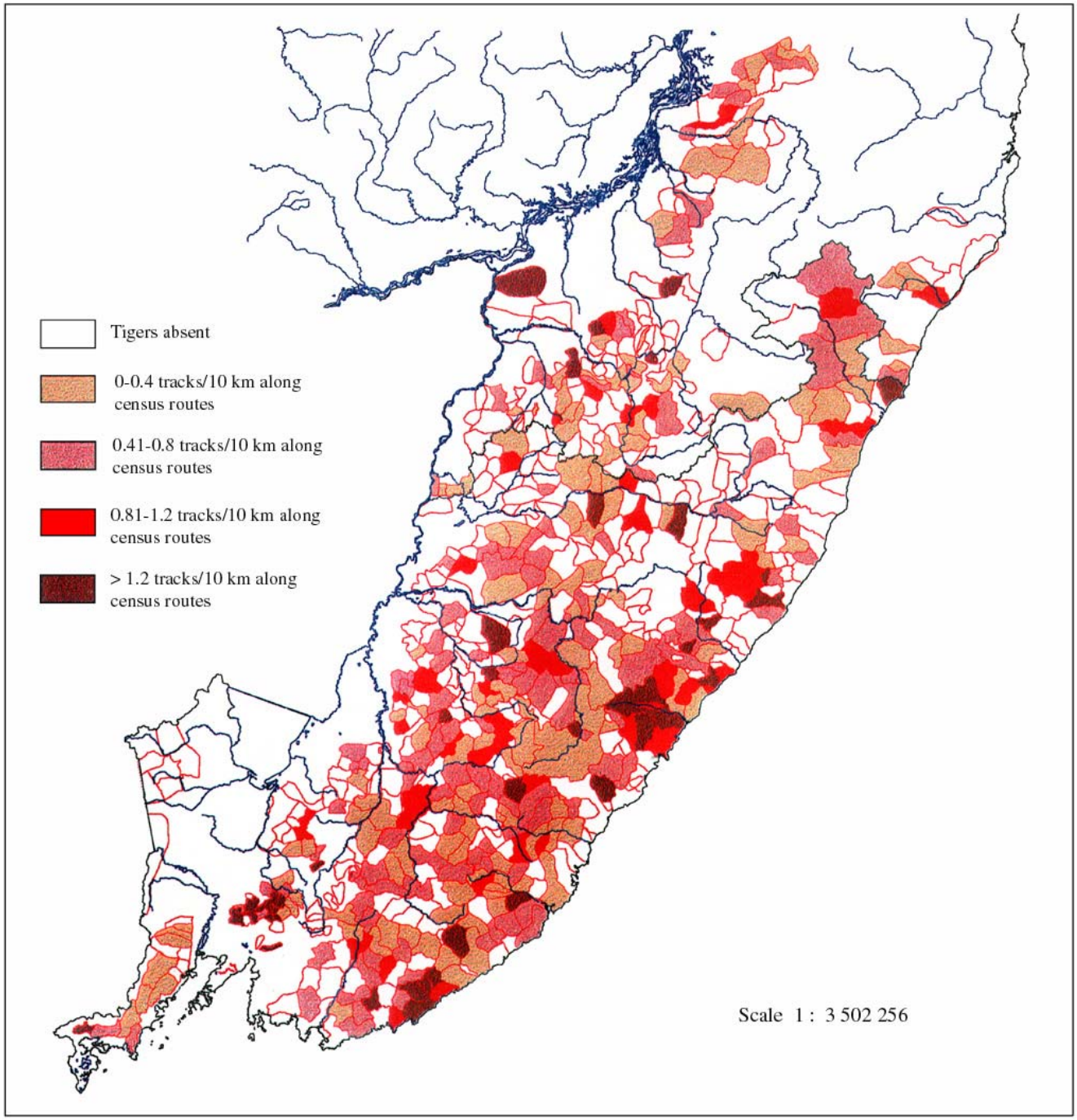
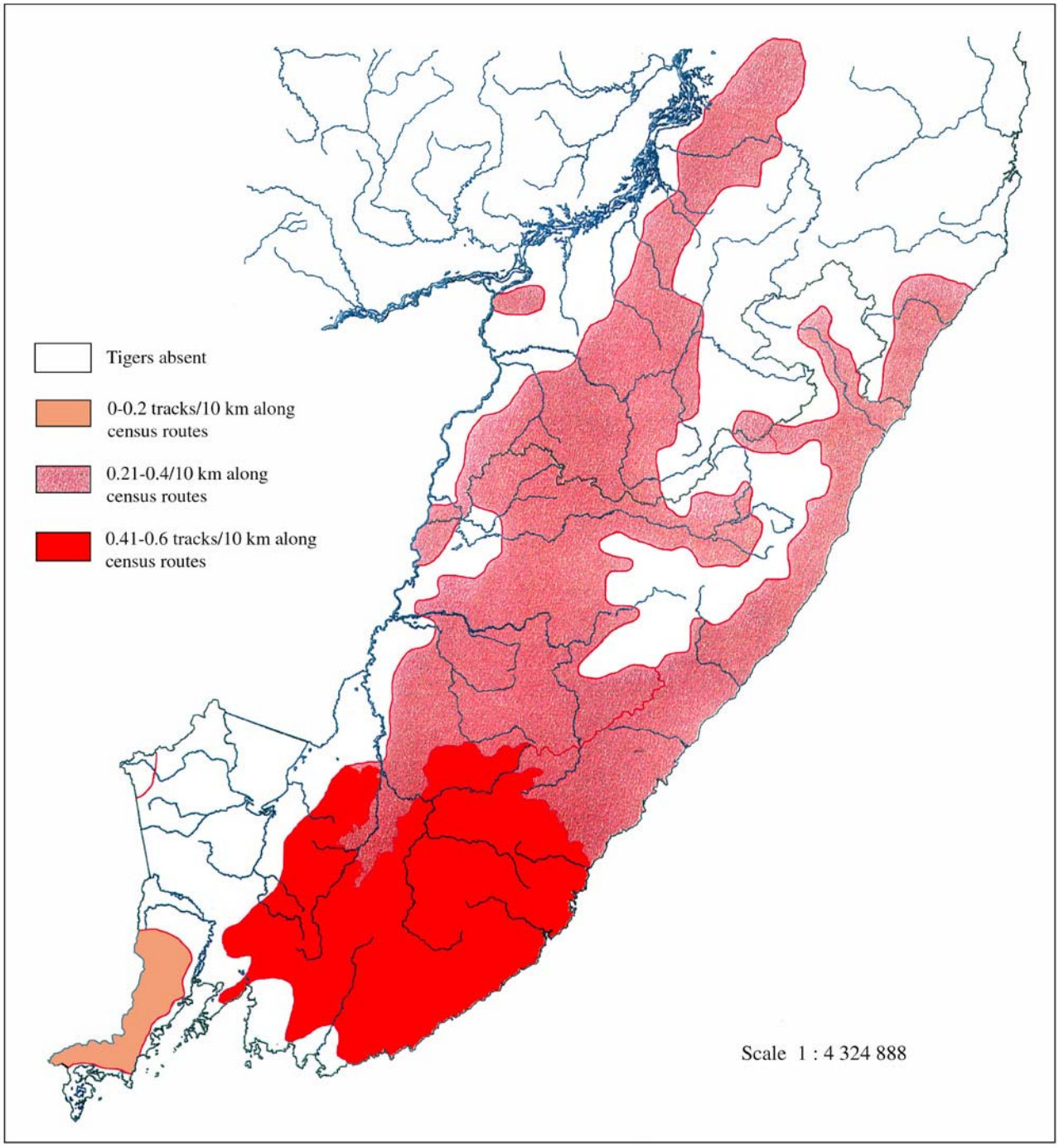


Figure 4. Density of Amur tiger tracks, by region (raion groups), based on tracks from simultaneous count (February 10-12, 1996)



The total number of tigers in the Northwestern Raion Group was estimated at 108-133 individuals (Tables 4 and 5), including 32-35 males, 36-46 females, 20 individuals of undetermined sex and age, and 20-32 cubs. Average population density was 2.6-2.7 individuals/1000 km^2; with a maximum of 4.7 individuals/1000 km^2 in the Malinovka, Kabarga, Kedrovka, Zolotaya, and upper Okhotnichya Basins (Table 4).

A decrease in tiger numbers in the region probably began in the early 1990's. The status of the prey base throughout this region is generally poor, and can be considered critical in the number of places. In some places densities of wild boar and elk has decreased drastically.

The following general tendencies were noted in the Raion Group:

1. In comparison to 1979 and 1985, the number of litters has decreased. For example, in the middle and upper Bikin Basin previous censuses indicated 5-7 tigresses with litters, but the 1995-1996 census revealed only three tigresses with cubs in the same region at the beginning of the winter. By the end of January and during the simultaneous count, no tracks of litters were encountered, and their fate remained unknown.
2. The population decreased slightly in the central portion of the territory along the central basins, with a relative increase in the upper reaches of basins. This change was probably associated with a decrease in the number of wild boar, worsening of habitat quality, and greater frequency of tiger poaching near settlements.
3. On the whole, the number and density of this subpopulation is close to the 1985 level. Intensified poaching and increasing frequency of conflicts between tigers and humans has probably prevented any potential increase in tiger numbers. Conditions for tigers are worsening especially in the more populated western part of this region, where ungulate numbers decreased to very low levels after the extremely snowy winter of 1994-1995.

Southern Raion Group. This raion group includes the southern and southwestern Sikhote-Alin Mountains, and Ussurisky Zapovednik. Within existing tiger range this region is under the most pressure. This is the most heavily populated area of the Russian Far East, and consequently, high levels of disturbance, low and unstable numbers of ungulates, and systematic official and unofficial hunting of tigers has put a constant strain on the tiger population. Habitat conditions for tigers are deteriorating. Liquidation of former infrastructures controlling use of natural resources, and the recent collapse of a legal framework for managing hunting units, has resulted in decreased protection of wildlife and of all natural resources, including the tiger. This situation is typical over the entire range of tigers, but especially critical in this raion group.

Suitable tiger habitat was divided into 112 count units covering 941,000 ha of suitable tiger habitat. A total of 70-79 tigers was counted in this region, including: 19-23 males, 21-26 females, 11 cubs, and 19 animals of undetermined sex (Tables 4 and 5). Regional coordinators and their assistants believe the tiger population in this raion group is currently in a "depressed" condition: a small percentage of the females were with litters, which usually consisted of only one cub, while at the same time a high percentage of the population is adult males. This situation appears to be due to an insufficient prey base (ungulate densities are low here) and shooting of tigers. Ussurisky Zapovednik has a well preserved natural ecosystem, but it is a very small area (40,432 ha). Nonetheless, there is a concentration of tigers here because it is the only remaining reserve in the raion group. In the last 5-7 years there has been significant decreases in tiger habitat and tiger numbers. If the present trend continues, in 4-5 years tigers will be a rarity in the southern Sikhote-Alin region.

Northeastern Raion Group. This region includes Sikhote-Alin Zapovednik, which perhaps represents the best remaining habitat within the present range of the Amur tiger. This conclusion is confirmed by all censuses, including this one, conducted in the Russian Far East.

Figure 5. Distribution of tigers in Primorye and Khabarovsk Krais, based on the 1995-1996 winter count

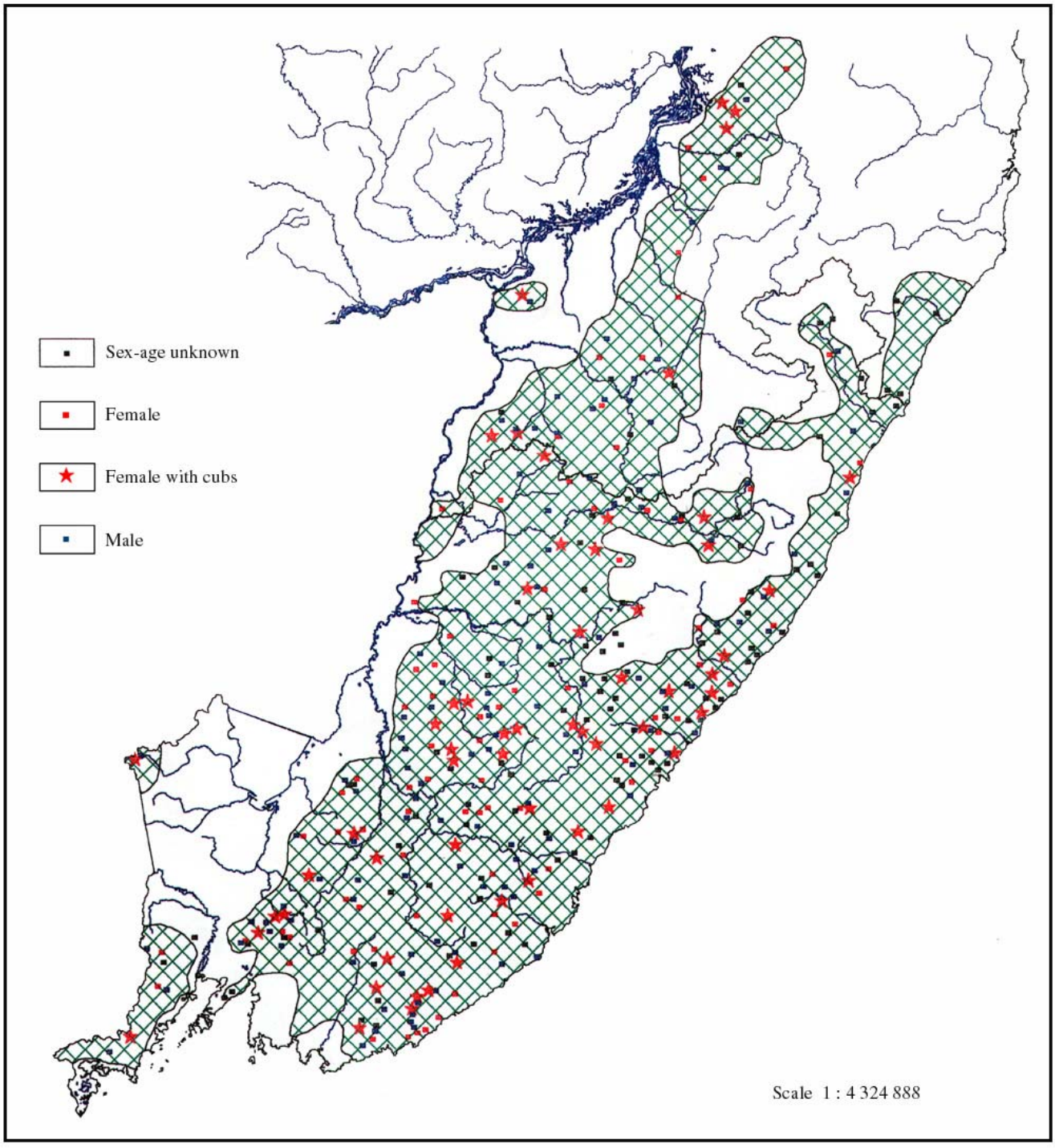
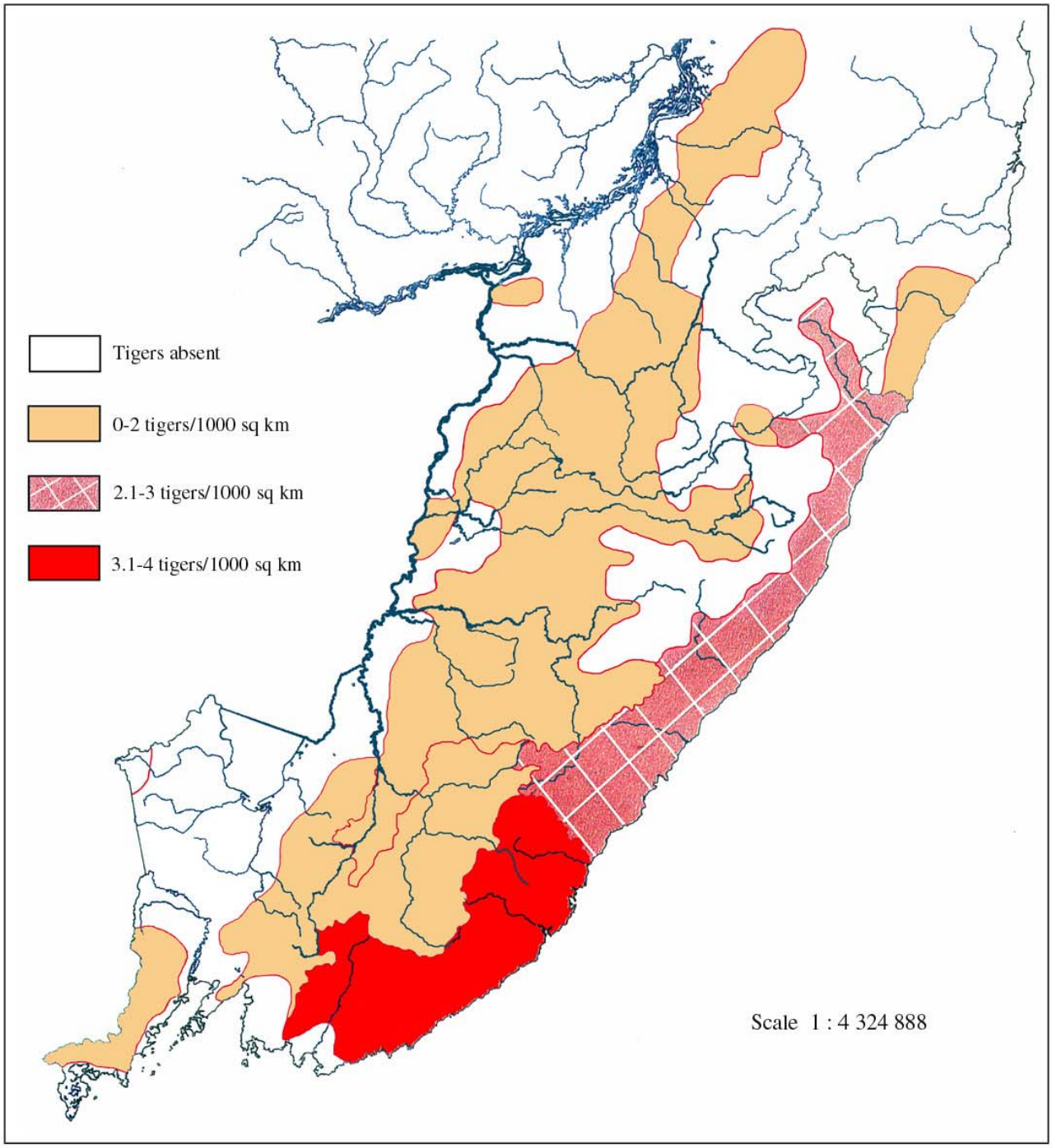


Figure 6. Density of tigers, by region (raion groups) in Primorye and Khabarovsk Krais, based on data for the 1995-1996 winter count



The census results are as follows. Approximately 75% of Terneisky Raion were surveyed. Relatively large "blank spots" occurred in the upper reaches of Samarga, Maximovka and Velikaya Kema River basins. The same situation was common in Krasnoarmeisky Raion where approximately 3000 km^2 of the Upper Arma was not surveyed. However, according to all available information and reports of local hunters, sign of tigers is rarely observed in this region.

There were considerable difficulties in organizing the census in Dalnegorsky Raion, and consequently, only the simultaneous census was conducted on most of this territory. Due to the high human density, well developed industrial complex, dense network of roads, high logging activity (and a resulting low density of ungulates), there were few tigers reported in this region. Difficulties in organization are probably similar to those observed throughout Primorsky Krai, and are largely related to the dissolution of the wildlife management structure (upon which earlier censuses were based).

The simultaneous count was conducted in all 92 count units in this raion group, and the all-winter count was conducted in 85 of those units. Approximately 80% of the raion group were surveyed. Weather conditions were good for the census: snow cover averaged 15-20 cm in the southern part of the region and 50-60 cm in the northern and upper portions of the river basins.

Sex and age structure of the 86-98 tigers counted in this raion group was: 13-17 males, 22-26 females, 32 individuals of undetermined sex, and 19-23 cubs (Tables 4, 5, and 6).

In general, the tiger population in this raion group appears to be on the rise: in the south, the density has stabilized and a steady increase is being observed in the north. The region can be ostensibly divided into two parts: the Zapovednik and adjacent territories, and other regions. The Zapovednik and adjacent territories are well-protected lands with high ungulate densities, and consequently more than half of all tigers counted use this area, even though it comprises less than 30% of the raion group. Outside the Zapovednik and adjacent areas, where there is presently little protection, the existence of tigers can only be attributed to the low human population inhabiting the taiga. There exist several serious threats to the future conservation of the tiger in the region. Two such threats for tiger survival are the plans for development of the Sukpai-Agzu-Nelma road (opening up one of the last unlogged river basins, the Samarga, to exploitation) and the activity of the joint Russian-Korean logging enterprise "Hyundai" in Svetlaya. The Svetlaya port has become an open market for exporting tiger products to Korea and China.

Southeastern Raion Group. This region, including Lazovsky Zapovednik plays a very important role in tiger conservation, as indicated by the results of the present and three previous censuses. Density of tigers is similar to that observed in the Northwest and Northeast Raion Groups, and Lazovsky State Zapovednik represents some of the best available habitat, comparable to Sikhote-Alin Zapovednik and the middle Bikin Basin. Habitat conditions here are especially favorable for tigers, although this region is more highly developed and densely populated than the raion groups to the north. Since the early 1970's, there has been a consistent increase in tiger numbers, especially in the Zapovednik and adjacent territories. Population growth probably proceeded into the early 1990's. With the dramatic increase in tiger poaching (beginning in the early 1990's), tiger numbers have decreased throughout the Southeast except within the Zapovednik.

Results of 1995-1996 census indicated 80-82 tigers in this raion group: 21-22 males, 23-24 females, 23 cubs, and 18 tigers of undetermined sex (Tables 4, 5, and 6). Tiger distribution in the southeast is not even. Maximum population density (5-7 individuals/1000 km^2) exists within Lazovsky Zapovednik and adjacent territories; in unprotected areas, density ranged from 2 to 4 individuals/1000 km^2. A decrease in ungulate numbers has been noticed throughout the entire raion group except within the Zapovednik. The abundance of tiger prey is probably inadequate, although the region differs from the others in that there exists relatively high numbers of sika deer and goral.

The status of the tiger population in the Southeast is adequate, although the majority of fieldworkers noted a decrease in tiger numbers since 1989-1990. All available habitat appears to be filled, so that population numbers are regulated by both trophic factors and intensive poaching.

Table 6. Data on sex-age composition of tiger population, based on maximum population size

Krai	Raion group	Raion	Total number of tigers	Percentage of population			
				Adults			Cubs
				Males	Females	Unknown sex	
Primorsky	Southwestern	Khasansky	6	33.3	33.3	16.7	16.7
		Nadezhdinsky	1	0.0	100.0	0.0	0.0
		Ussurisky (west)	2	50.0	0.0	50.0	0.0
	Western	Pogranichny	4	25.0	25.0	0.0	50.0
	Southern	Vladivostok outskirts	2	0.0	0.0	100.0	0.0
		Anuchinsky	11	27.3	36.4	18.2	18.2
		Mikhailovsky	5	40.0	20.0	0.0	40.0
		Ussurisky (east)	7	28.6	28.6	28.6	14.3
		Shkotovsky	9	22.2	44.4	22.2	11.1
		Chernigovsky	4	75.0	25.0	0.0	0.0
		Spassky	7	42.9	28.6	28.6	0.0
		Chuguevsky	34	23.5	35.3	26.5	14.7
	Southeastern	Kavalerovsky	19	26.3	26.3	31.6	15.8
		Olginsky	21	28.6	28.6	28.6	14.3
		Lazovsky	33	30.3	30.3	6.1	33.3
		Partizansky	9	11.1	33.3	44.4	11.1
	Northeastern	Dalnegorsky	13	7.7	15.4	23.1	53.8
		Terneisky	85	18.8	28.2	34.1	18.8
	Northwestern	Krasnoarmeisky	44	18.2	29.5	22.7	29.5
		Pozharsky	41	29.3	26.8	19.5	24.4
		Dalnerechensky	28	28.6	46.4	3.6	21.4
		Kirovsky	8	62.5	37.5	0.0	0.0
		Lesozavodsky	2	0.0	100.0	0.0	0.0
		Yakovlevsky	10	20.0	40.0	10.0	30.0
Khabarovsky	Northern	Bikinsky	4	25.0	25.0	25.0	25.0
		Vyazemsky	10	50.0	30.0	10.0	10.0
		in-the-name-of Lazo	29	20.7	20.7	31.0	27.6
		Khabarovsky	4	25.0	25.0	0.0	50.0
		Nanaisky	18	33.3	33.3	5.6	27.8
		Komsomolsky	2	0.0	50.0	0.0	50.0
		Sovgavansky	4	0.0	0.0	100.0	0.0
Total			476	25.3	30.3	22.5	21.9

Khabarovsky Krai

Northern Raion Group. A minimum of 64 tigers was estimated to reside in Khabarovsk Krai in the winter of 1995-1996, including 8 cubs (6 litters) and 8 young animals that were categorized as cubs based on the standardized criteria. It is likely that only 3 of these 8 young animals were in reality cubs: the other 5 were likely individuals of undetermined sex, whose small track size were actually measurement errors. Additionally, 4 adult individuals and one adult female with two cubs were classified as questionable. Among them was a female that used the Upper Gorbun Basin (Bikinsky Raion) and may also have used adjacent Primorye basins (and thus be counted twice); females in units 21-47 (Podhoryonok-Matai) were identified as two different individuals based on the criteria (they may have been one animal); two individuals of undetermined sex using units 98-99 (Nelta-Moken); and a male in unit #85 (Matai, Ivanov Creek).

Several mistakes may have been made during the collection and processing of information. Reports of two females with cubs at Soi most likely represent two lynxes that passed along tiger tracks; a female in the Upper Gorbun is likely animal #3 from count unit #9, and the other animals either traveled widely or were incorrectly located on maps. Despite these potential errors, the maximum count in the winter of 1995-1996 is no more than 71 individuals. It is preferable to use the minimum value, 64 individuals, as a more conservative estimate.

Population density averaged 1.6 individuals per 1000 km^2 (Table 5). Density was at a minimum on the periphery of tiger range and practically equal elsewhere, if Khabarovsky Raion - where tigers live in an isolated habitat fragment on the Big Khekhtsir Range - is not included. Tigers in the Big Khekhtsir Range and adjacent regions are probably unimportant, as they are likely to soon disappear. According to archival material, animals had been absent in this territory since 1937, yet appeared again after more than 50 years. At the time of the census, the area inhabited by tigers in Khabarovsky Krai was 33,633 km^2, representing 61% of potentially suitable tiger habitat (55,000 km^2). The term "suitable" tiger habitat is difficult to define in Khabarovsky Krai as because tigers presently inhabit some forested regions where the species was absent at the end of the 1980's, a time when the tiger population was at a maximum.

The second indicator, area presently inhabited by tigers, is more suitable for analysis. In comparison to data from 1993-1994, the distribution of tigers in the southern part of the Krai has contracted 20.4%, in Komsomolsky Raion 47.6%, and in Sovgavansky Raion only 13.7% (either the population increase continued longer here or coverage of this raion was insufficient in the 1993-1994 census). In Nanaisky Raion and Raion in-the-name-of Lazo, the decrease in distribution is probably seasonal, and caused by deep snows in the mountains. In these two raions, no major changes in the range of tigers was noted, except for habitat contraction in the already fragmented Sukpai Basin. However, habitat losses were quite obvious in Vyazemsky and Bikinsky Raions, where tigers abandoned development sites along the mountain bases. Consequently, the range boundary has shifted to the east. In Komsomolsky Raion the same kind of development has contracted the range boundary to the south. These changes may be a result of stabilizing numbers and a tendency for decrease in numbers at the center of the range. It is likely that tiger distribution will continue to shrink in the future.

Based on the fact that there has been a considerable decrease in cattle depredation, the number of tigers entering settlements, and the number of "wandering" tigers (animals without a permanent home range), it can be concluded that the number of tigers is close to being balanced with the density of prey populations, with a slight predominance of predators. The present situation also suggests that, when the tiger population reached a maximum (1987-1990), there were likely 90-100 individuals in Khabarovsky Krai, and density throughout much of the range was practically the same: 2.2-2.4 individuals/1000 km^2. However, in the central part of the range tiger density was likely twice these estimates. We can estimate the potential number of tigers in Khabarovsk Krai with an extrapolation based on the present-day area of suitable habitat and average density of tigers. This estimate, 120-130 animals, is approximately 2.5 times less than the number estimated for the middle of the 19th century, and approximately twice more than the present census indicated.

It should be noted that not all 64 tigers occurred only within the territory of Khabarovsky Krai. In Bikinsky, Vyazemsky, and in-the-name-of Lazo Raions, 8-10 animals commonly ranged into Primorsky Krai. Movements are most typical in the first half of winter before deep snows cover mountain passes. Therefore, in November there is typically an "invasion" of predators. Wandering and dispersing tigers arrive from the Bikin, Samarga, and Edinka Basins. This pattern was especially noticeable when the tiger population was increasing, and new animals appeared through ecological corridors near Podhoryonok, Matei, and Katan. It was probably these animals that ended up in Solontsovy, Shumniy, Vyazemsky and a number of other smaller villages. If there is a dramatic decrease in tiger numbers, a reverse process may be predicted, that is, a shrinking of tiger range in towards optimal habitat.

The sex-age structure of the population in Khabarovsk Krai group was: 20 males (31.2%), 17 females (26.5%) (including 6 females with cubs - 9.4%), 11 adult and subadult individuals of

undetermined sex (17.2%), 16 cubs (25.0%) (including 8 cubs still with tigresses - 12.5%). These results are based on data provided by fieldworkers and subsequently checked by coordinators with specific criteria. Assessment of sex and age structure with this kind of data is difficult, and there is the potential for many errors. Nevertheless, the sex ratio of the adult population indicating a majority of males (1:1.18) is consistent with the results of our analysis on sex composition of litters during a period of low numbers, beginning in the 1960's, also indicating a predominance of males (1:1.2). The number of cubs determined to be traveling without females is unlikely. As mentioned above, this number is not likely to exceed 3 individuals according to verifiable data. If we make such an adjustment in the data, there would be 5 less cubs, and 5 more animals of undetermined sex. Consequently, cubs would comprise 17.2% of the population, instead of 25%. The category "individuals of undetermined sex" includes both young males and subadult females. If we assume that the average percentage of cubs in the population has been no more than 20% for the last two years, then on the whole young animals of undetermined sex should represent about 30% (19-21 individuals) of the population, taking into account mortality.

Thus, the territory of Khabarovsk Krai was inhabited by 45-50 adult tigers at the end of the 1996 winter, including 20-23 mature females. Consequently, tigresses with litters comprised 26-30% of the population. The average litter size was 1.33 cubs/adult female by the end of the winter. According to these calculations, reproductive output in the last year was far below the potential. It appears that in the last three years reproduction approximately equaled mortality; consequently population growth is likely only in the areas with especially favorable conditions.

In summary, results of the 1995-1996 winter census of Amur tigers in the Russian Far-East indicated the following:

males	**108-121;**
females	**132-143** (**52-58** with cubs);
undetermined sex	**90-107;**
cubs	**85-105,**

and a total of **415-476** Amur tigers within the Russian Far East.

A breakdown for each of the Krais indicates the following:

in Primorsky Krai:

adult tigers (includes subadults)	**282-318;**
cubs	**69 - 87;**
total number in Primorye Krai	**351-405;**

in Khabarovsky Krai:

adult tigers (includes subadults)	**48 - 53;**
cubs	**16 - 18;**
total number in Khabarovsky Krai	**64 - 71.**

Total population of adults and subadults	**330-371.**
Total population of adults, subadults and cubs	**415-476**

Data on the sex-age structure of the population is presented in Table 6 by raion and raion groups. Population density was calculated for the adult segment of the population, including individuals of undetermined sex and age. Maximum adult tiger density estimates (including animals "questionably identified") were calculated for in Tables 4 and 5, but minimum density estimates (without questionably identified" individuals) are used in Figure 6.

Table 7. Geographic variation in litter size of Amur tigers, based on reports of fieldworkers for the period 1985-1996

Raion group	Litter size								Average litter size	Variation from total average litter size (%)
	One		Two		Three		Four			
	Number	%	Number	%	Number	%	Number	%		
Southwest	15	62.5	8	33.3	1	4.2	0	0.0	1.42	-16.5
West	2	50.0	2	50.0	0	0.0	0	0.0	1.50	-11.8
South	35	46.7	37	49.3	2	2.7	1	1.3	1.59	-6.5
Southeast	39	33.3	62	53.0	14	12.0	2	1.7	1.82	+7.0
Northeast	8	27.6	18	62.1	3	10.3	0	0.0	1.83	+7.6
Northwest	51	33.1	80	51.9	21	13.6	2	1.3	1.83	+7.6
North	49	39.2	68	54.4	8	6.4	0	0.0	1.67	-1.8
Total	199	37.7	275	52.0	49	9.3	5	1.0	1.70	

4.2 Analysis of data on litter size

Information on 528 litters of tigers over the last 12 years was reported in field diaries by fieldworkers (mostly hunters) and wildlife management specialists who personally saw tracks of females with cubs in their hunting sections. Because the data is based on personal observations, we believe it is fairly reliable. It is likely that many litters were reported by several people. However, we were able to conduct a "retrospective" analysis, which, while it may not be extremely accurate, nonetheless can act as an indicator of geographic variation and dynamics of Amur tiger reproductive parameters (Table 7). The data allow us to compare trends in reproduction performance of the population on the periphery of the range and in the center of the subspecies distribution. Average litter size across raion groups varies by as much as 22% (Table 7). Lower productivity in the southern part of the range may be one reason why there has been a decrease in numbers in such raions as Mikhailovsky, Chuguevsky, Anuchinsky, and Shkotovsky, where, 10-15 years ago, density was the highest.

Analysis of geographic variation in reproduction indicates regions of high productivity, and provides an indicator for prioritizing areas needing protection. Average litter size was largest in the Southeastern Raion Group of Olginsky, Partizansky, and Lazovsky Raions; in the Northeastern Group in Terneisky Raion, and in the Northwestern Group including Dalnerechensky, Krasnoarmeisky, and Pozharsky Raions. Based on litter size it is determined that the best "tiger" raions in 1996 were Olginsky, Partizansky, and Dalnerechensky. In other words, within each raion group there is a pattern similar to that observed over the entire range: a decrease in reproductive output from the center to the periphery of a region. This fact can be clearly demonstrated by looking at litter size in each raion of the large Northwestern Raion Group: Pozharsky - 1.77; Krasnoarmeisky-1.80; Dalnerechensky - 1.94; Lesozavodsky - 1.8; Kirovsky - 1.78; and Yakovlevsky - 1.67. This variation can be explained by geographic variation in habitat quality: in the higher mountains there is more snow and fewer prey, while in the lower reaches of basins human disturbance is greater. The middle sections of river basins represent the "golden center".

Table 8. Changes in average litter size of Amur tigers from 1991-1996 over their entire range

Year (winter season)	Litter size								Average litter size	% change from previous year
	One		Two		Three		Four			
	Number	%	Number	%	Number	%	Number	%		
1991	11	42.3	12	46.2	2	7.7	1	3.9	1.73	
1992	12	50.0	11	45.8	1	4.2	0	0.0	1.54	-11.0
1993	11	22.5	32	65.3	6	12.2	0	0.0	1.89	+18.5
1994	25	36.2	38	55.1	4	5.8	2	2.9	1.75	-7.4
1995	63	42.0	79	52.7	7	4.7	1	0.7	1.64	-6.3
1996	36	62.1	19	32.8	3	5.2	0	0.0	1.43	-12.8
Total	158	42.0	191	51.0	23	6.1	4	1.1	1.66	

These regions are responsible for producing the majority of young, but unfortunately, such "reproduction centers" are contracting in size.

An analysis of changes in tiger litter sizes over years (Table 8) suggests that, since 1993, there has been a steady decrease in the reproductive rate, on average, by 8.8%. It is interesting to note that the number of elk and wild boar in Khabarovsky Krai is also decreasing at approximately the same rate. We can use this data to predict that litter size will likely decrease to an even smaller average size in 1996-1997. An increase in the number of wild boar and a stabilization of the elk population at low levels in the coming 2-3 years could be a stimulus for tiger reproduction (or for an increase in survival), but it is not likely to result in an increase in population size. After this period, there is a high probability that insufficient food resources will result in increased depredations by tigers, and a greater threat to human life, thus forcing an increase in official shootings.

The average litter size of Amur tigers in winter was 1.66-1.7 cubs. More than half of all females (52%) have 2 cubs, even in winter when some mortality has already occurred (Table 7).

According to our long-term observations, annual loss of cubs ranges from 16.0 to 26.4%. The higher mortality estimate was based on data obtained in Khabarovsk in 1994, when 18 of 34 cubs died over a two year period. Presently, litter size (at birth) is estimated at 2 to 2.3 cubs, but only slightly more than one individual reaches the age of sexual maturity. An attempt to track changes in litter size through the winter (Table 9) does not provide a clear picture due to the insufficient number of observations in October, March, and April, when there is no snow and few hunters in the taiga. If data for November and February are representative, the results indicate a tendency for litter size to decrease approximately by 6.8%. These results, and additional data from Khabarovski Krai, indicate that no less than 15% of cubs are lost in winter.

Monitoring litter size provides important information for understanding the dynamics of reproduction in the Amur tiger population, and for predicting changes in population size. Moreover, this type of information is considerably easier to obtain than a complete census.

Information provided by zoos and publications indicate that the sex ratio of cubs is close to 1:1 at birth. Data based on capture of 142 cubs in the wild confirms that on average equal numbers of males and females are born in the wild. However, sex ratios change over time: female cubs were more common up until 1947 (1:0.67), from 1947 to 1970 males were the majority (1:1.5), and from 1975 to 1989, during a period of rapid population growth, females dominated again (1:0.65 - 20 females and 13 males out of 43 captured animals). Since 1990-males were again more common (1:1.2). This information is especially important for understanding mechanisms of change in tiger numbers and for predicting future trends. Periodic increase in the female proportion of the population, a reduction in age at first breeding, (noted, for instance, by various scientists at the end of the 1980s), and an increase in litter size are the three factors that can boost the reproductive rate and result in rapid population growth. Apparently, population increase is also a response to an

Table 9. A summary of changes in litter size of Amur tigers through the winter season, 1991-1996

Parameter		Month							% change
	n	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Dec.-Apr.
Number of litters	266	16	71	89	46	32	9	3	
Total number of cubs	437	24	124	149	72	51	12	5	
Average litter size		1.50	1.74	1.67	1.56	1.59	1.33	1.66	-12.4

increase in food resources and a “open niche”. Supporting evidence comes from the fact that density of wild boar occurred at the end of the 1960’s. Elk numbers were probably also at a maximum at this time, or, in any case, no less than 3 times as high as present numbers, based on census plots in Khabarovsky Krai.

In the early 1990’s, a natural decrease in tiger numbers coincided with an unprecedented increase in poaching. Similar scenarios are typical for virtually any species that is commercially exploited. As more people become involved, the more effective the exploitation becomes, but, as a rule, improvement of hunter abilities, additional equipment, and use of special capture equipment reach their highest level of intensity late, when the animal population is already decreasing. Analogous patterns associated with population peaks and decreases are well known in predator-prey systems.

Judging by the present-day sex ratio and a natural decrease in population growth rates, the tiger population is presently going through a period of stabilization, with a negative growth rate that is largely a result of decreasing habitat quality and quantity, and on-going poaching.

4.3 Data on tiger mortality

By 1985 a major decrease in wild ungulate numbers occurred within tiger range due to a series of hard winters. At the same time, conflicts with human beings, depredation on domestic animals and at deer farms, and tiger incursions into villages became more frequent. As a consequence, the number of official and non-official shootings has increased (Table 10).

By the beginning of the 1990’s ungulate numbers had increased or stabilized in many raions. At the same time, that segment of the tiger population that was accustomed to cattle-depredation and entering settlements had been largely removed. However, a new threat developed, namely commercial poaching, which arose from the new-found possibility of selling tiger products abroad (pelts and derivatives of tiger carcasses). Tiger bones and other parts of the carcass have always been in high demand in many Asian countries, where they are considered to be one of the most valuable ingredients in traditional Asian (Tibetan) medicine. Expanding international ties provided an easy avenue for moving tiger products through Vladivostok and Khabarovsk.

The information presented in Table 10 is based on responses of fieldworkers to the question in the field diary: "Do you know any cases of tiger deaths?". We believe this summary is far from complete. More than 90% of the fieldworkers did not answer the question, or gave information that was already generally well-known. According to other calculations, an average of 40 to 50-70 tigers could have been killed annually (Pikunov 1994, Nikolaev and Yudin 1993). This estimate, together with natural losses, may exceed the reproductive potential of the population.

Considering the results of the present tiger census, the sex-age structure of the population, its reproductive potential, and comparison of the results with the previous census of 1984-1985, it is likely that one of the main factors regulating tiger numbers in Russia today is poaching caused by a great demand and high prices of tiger products.

Table 10. Summary of tiger mortalities during past 10 years, based on information supplied by counters during the 1995-1996 winter census in Khabarovsk and Primorye Krais

Cause of death	Primorski Krai		Khabarovski Krai		Total	
	1985-1990	1991-1996	1985-1990	1991-1996	1985-1990	1991-1996
Human-caused death:						
Official permit for shooting*	23	6	6	7	29	13
Depredation killing	3	0	0	10	3	10
Poaching	25	52	0	19	25	71
Other**	25	66	0	0	25	66
Total human-caused deaths	76	124	6	36	82	160
Natural caused deaths:						
Tiger	2	2	3	4	5	6
Bear	2	2	2	1	4	3
Wild boar	2	2	0	0	2	2
Starvation	2	2	0	2	2	4
Other	0	3	0	0	0	3
Total natural caused deaths	8	11	5	7	13	18
Unknown	10	9	1	6	11	15
Total	94	144	12	49	106	193

*official records for Prmorsky Krai from Hunting Management Board (1986-1990) and Primorye Krai Committee for Nature Protection (1991-1996).

** includes reports with incomplete information; usually reported as "shot" or "killed".

5. Discussion of results and conclusions

According to the results of 1995-1996 winter census, the range of Amur tigers in the Russian Far East occupies an area of approximately 156,500 km^2, including 123,000 km^2 in Primorsky Krai, and 33,500 km^2 in Khabarovsky Krai- (Table 5, Figure 2). It appears that animals inhabit nearly all forested lands within the present range (at least periodically). Potential fragmentation points of the population within the massive Sikhote-Alin Range are not significant or are stable. Thus, for the most part this territory has retained its integrity to date, with the exception that at the northern limits of tiger range, fragmentation of some localized subpopulations is occurring (in the Sukpaiskaya, Samarginskaya, Botchinskaya regions) that could result in complete isolation from neighboring subpopulations. However, localized habitat fragments associated with small, isolated mountain ranges -Samursky and Khekhtsirsky- separated from the Sikhote-Alin, have already become “islands” (Table 11). Isolation of the Western (Pogranichny) and Southwestern habitat fragments from the main population is even more dramatic. Contact between these isolated subpopulations with the main population in Sikhote-Alin is possible by dispersers and nomadic individuals that are

always present in the population. This category of animals includes young animals starting an independent life, adult males, and occasionally, even females with cubs. However, during the period of the census, there were no resident individuals located in potential contact zones between habitat fragments and the main range.

The potential for range fragmentation is not yet a threat throughout the greater portion of Sikhote-Alin. Though there exists great ecological variation within this mountainous landscape, the Amur tiger population still retains its integrity as a single population. At the same time, fragmentation points are appearing; one of which, near Svetlaya in Terneisky Raion, threatens to separate the above-mentioned Samarginskaya subpopulation. This danger is also very real for the "Sinegorskaya" subpopulation in Spassky and Chernigovsky Raions of Primorye, and for the Anyuiskoy subpopulation in Khabarovsky Krai. If these small subpopulations ever become isolated, they are likely to quickly disappear.

Tiger distribution in the Sikhote-Alin Mountain Range, as revealed by the census, confirmed that highest densities occur on zapovedniks (Sikhote-Alin, Lazovsky, and Ussurisky Reserves) and areas adjacent to them (Figure 6). The same trend was noted in previous censuses, but the difference was less dramatic. For example, in the 1970-1980's large areas of unprotected lands were also considered high quality habitat (the middle Bikin Basin, the Malinovka (Vaku), Ussuri and other river basins). The growing discrepancy is likely caused primarily by poaching, and secondarily by deteriorating habitat conditions on unprotected lands. Degradation of tiger habitat, and a reduction of suitable habitat for this species will inevitably continue. Despite this, existent zapovedniks cannot guarantee survival of the Amur tiger because their combined area is too small and disconnected. In order to resolve this problem a network of large, interconnected tiger "reservations" must be established which includes zapovedniks as core areas. A limited land-use regime would be implemented over much of the reservation lands. Delineation of large "protected zones" was proposed following the results of 1984-1985 census (Pikunov and Bragin 1985, Pikunov 1990). A more relaxed, traditional land-use regime can be applied for ecological corridors that link main reservations into one system. At the same time, it is important to raise the prestige and status of hunting (wildlife) management organizations, increase ungulate densities on hunting territories, more strictly regulate hunting, and forcefully suppress poaching.

The last detailed inventory of the tiger population in Primorsky Krai (1984-1985) indicated that tigers occupied approximately 110,000 km^2. The slight increase in tiger range (to 123,000 km^2 in Primorye) reflects the range expansion in northern Sikhote-Alin, into marginal tiger habitat, such as the Samarga Basin, the Upper Bikin, Big Ussurka, Ussuri, etc. Possibly, this expansion occurred simultaneously with the decrease in tiger densities in more typical regions along the central portions of river basins. In regions newly colonized by tigers, heavy snow winters typically result in a decline in their number, especially if associated with a decline in previous years of the key prey species - wild boar and elk.

Estimation of tiger numbers was based on a procedure, which included, as an essential component, the coordinator's knowledge and experience of the peculiarities of tigers in each count unit. In addition, as mentioned above, during data processing, and prior to analysis, a new system of rigid criteria was developed for identifying individual tigers. This new system consisted of two sets of criteria: "soft" and "hard" (which resulted, respectively, in larger and smaller estimates of population size). These criteria were based on an assessment of changes in track parameters, 24-hour linear movements for males and females, total home range size, and other measurements. The values for these criteria was taken from published materials and unpublished data from radio-tracking studies on tigers in Sikhote-Alin Zapovednik. The criteria provided clear orientation points, and a single methodology to assess census results by different coordinators.

For the majority of coordinators, results of using the traditional census technique to count tigers fell between the ranges determined by the hard and soft criteria. However, within zapovedniks, without exception coordinators' estimates exceeded those based on the set of soft

Table 11. Locations and characteristics of isolated or partially isolated fragments of Amur tiger habitat

Habitat	Location	Occupied habitat (km2)	Population density (tigers/1000 km^2)	Characteristics and Status
Southwestern	Khasansky, Nadezhdinsky, Ussurisky Raions, Primorsky Krai	4080	1.6	presently stable, isolated
Pogranichny	Pogranichny, Khankaisky Raions, Primorsky Krai	635	0.8	periodic extinctions
Alchansky	Mountain range Samur	845	1	tigers appear periodically conditionally isolated. constant threat of disappearing
Bolshe khekhtsirsky	Khekhtsir Mountains, Khabarovsky Raion, Khabarovsky Krai	580	5.1	unstable, isolated likely to disappear in near future
Botchinsky	Nelma, Botchi Sovgavansky Raion, Khabarovsky Krai	insufficient data	Insufficient Data	unstable, isolated. Appears when tiger population density increases in the center of habitat. Can be separated from Samarginski population
Samarginsky	Samarga, Edinka Terneisky Raions, Primorsky Krai	13 560	1.5	size of area reducing can be considered separate from Sukpaiski
Sukpaisky	Sukpai River Basin in-the-name of Lazo Raion Khabarovsky Krai	insufficient data	insufficient data	size of area reducing likely will disappear in 2-3 years

criteria. Obviously, an additional assessment is required for complete uniformity of census results. It is noteworthy that the ratio of tracks per positively identified individual varied among coordinators: from 10-11 tracks (Pikunov, Nikolaev) to 6-7 tracks (Smirnov, Salkina). Within regions assigned to each coordinator, usually 10 to 20% of suitable tiger habitat was not covered by the census due to variety of problems. Consequently, some underestimation of the population likely occurred in these areas. However, it is very likely that this error is compensated for by an overestimation in several regions. Thus, these errors likely negate each other, and do not greatly distort the results of the census.

A review of previous census data and other population estimates suggest that the Amur tiger population was increasing into the late 1980's. Since 1990-1991 a decrease in tiger numbers has been the result of a decreasing prey base and wide-spread poaching. Thanks to the efforts of scientists, international and Russian organizations, and a decrease in the demand for tiger products, poaching pressure has decreased, providing a basis for cautious optimism. Nonetheless, it is impossible to give a completely positive prognosis for the future. An imbalanced ratio between the tiger and key prey species is presently strongly pronounced in many regions, and conditions continue to worsen. Considering the present difficult economic situation, we can not count on quick, positive changes in hunting management, or the eradication of poaching. The strategy for tiger conservation must remain one of complete protection of the species.

The results of this census lay the foundation for delineating an extensive set of recommendations for tiger conservation. With the completion of the census, we now have a good estimate of the number of tigers in the Russian Far East, and where they are distributed. This information provides a basis for estimating the minimum viable population of tigers, and for delineating a conservation plan to insure the long-term survival of the Amur tiger.

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