Ecology and Conservation of the Siberian Tiger

Final Report To
Save the Tiger Fund at the National Fish and Wildlife Foundation
Project STF-95-166-002, Siberian Tiger Field Project
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EXECUTIVE SUMMARY

The Siberian Tiger Project has now completed more than four and one-half years of field work, along with almost two years of preliminary planning. During this reporting period, we continued to focus on the creation of the best possible data base for understanding Siberian tiger ecology, which will be used in the creation of plans for the future conservation of the animal in the wild. In addition to the field work, we began formal programs in conservation planning and environmental education.

The field program in the Sikhote-Alin Reserve added two additional study animals to the previous seven which were being radio-tracked. These two animals are important since they help fill the territorial matrix in the southern part of the study area. More than one-hundred and fifty locations were obtained on these animals, along with more than thirty kills, and the documentation of two matings and the production of three new litters to the adult females being radio-tracked. In addition, the digitizing of the cover map for habitat analysis has been nearly completed and now will allow us to determine those habitat types critical for tiger survival in the Russian Far East.

The conservation planning portion of the Project has produced an initial document for distribution in Russia. This document, A Habitat Protection Plan for the Amur Tiger, is a preliminary attempt to integrate field information on the tiger with range-wide land use planning for the species. The environmental education program produced a variety of product for distribution in the region, along with an art exchange and a survey of environmental education needs.

INTRODUCTION

This report covers the activities and accomplishments of the Siberian Tiger Project for the period April, 1995, through June 30, 1996. Since this document may be distributed to various readers, some of whom may have limited knowledge of our activities, we include information on the overall background and objectives of the Siberian Tiger Project. We hope this allows readers a greater appreciation of the scope of work the Siberian Tiger Project has undertaken, how the activities of the past fifteen months fit into the bigger picture, and a vision of where we are going with our Russian colleagues, not only in the conservation of the Siberian tiger, but natural resource conservation overall in the Russian Far East.

As we assess our achievements in our fifth year of the project, we feel much has been accomplished, and much is yet to be done. We have captured 13 tigers, 6 leopards, and nearly 20 bears for study and have accumulated a sizable body of data on these animals' activities. Our accomplishments have been not only in the realm of scientific field research. Due in great part to the attention focused on the Project, information concerning the plight of the Siberian tiger and the ecological crisis in the Russian Far East has reached the worldwide. With the data gathered to date, along with our in-depth knowledge of the area and the unique problems that exist there, we are in a unique position to develop and carry out conservation strategies for the tiger and the forest community upon which it depends. Our collaboration with the Wildlife Conservation Society, World Wildlife Fund-Germany and WWF-U.S., the U.S. Agency for International Development's EPT Project, along with close associations with the Russian Ministry of Ecology and the Far Eastern Branches of the Academy of Sciences, provide a solid foundation from which to continue a myriad of science and conservation activities.

The Hornocker Wildlife Institute's Far East Russian Program was born in 1988 around a campfire in the Idaho wilderness. The idea of a collaborative investigation of the Siberian tiger was proposed to some visiting Russian scientists. Though the idea had been intriguing to many scientists previously, few had attempted to begin such an activity. The objectives of the project were straightforward: to apply scientifically gathered information to the conservation of the subspecies. The goal from the beginning of the Project has been to provide the best possible information on the ecology and dynamics of the tiger population. This database would provide the foundation for conservation planning.

At the time of the initial contact with our Russian counterparts, the number of Siberian tigers in the wild was estimated to be between 400 and 500; more than ninety-percent of them inside the borders of Russia, in the Provinces of Primorye and Khabarovsk (see Attachment 1 and 2). This number was critically low, and conservation efforts were not underway. But conservation planning is only as good as the base of information from which it is developed. Although Russian scientists had gathered immensely important data on tiger ecology in the previous 20 years, it was limited by the fact that they relied on the traditional form of snow tracking (that is, following tiger tracks during the snow-bound months of the year). This meant that much of the annual cycle of life for the Siberian tiger was unknown. Moreover, specific individuals could not be tracked over long periods of time, an important element in describing the life history of a long-lived species such as a tiger. We proposed to bring Western technology and techniques to Russia, meld them with ongoing Russian work, and put the entire picture together through a joint effort.

With encouragement from their Soviet guests in 1988, Hornocker Wildlife Institute moved ahead with planning and fundraising. Despite the dissolution of the Soviet Union and a 1991 failed coup attempt in Moscow (among many other major obstacles), the Hornocker Wildlife Institute's Siberian Tiger Project survived. In 1992, field work commenced with a collaborative team consisting of representatives from Hornocker Wildlife Institute, the Sikhote-Alin State Biosphere Reserve, the Far Eastern Institute of Geography, and the Far Eastern Institute of Biology and Soils. These collaborations continue to be at the core of Project activities and successes.

As one of the very first American "ventures" in the Russian Far East, the Siberian Tiger Project was historic in demonstrating the feasibility of successful, cooperative work in the region. Later, a host of non-government organizations, the Peace Corps, the U.S. Agency for International Development, and even an American consulate became established in the Russian Far East. But the Hornocker Wildlife Institute led the way in establishing a presence in the region.

The scope of Hornocker Wildlife Institute involvement in the Russian Far East has expanded beyond the initial biological field investigations of the Siberian Tiger Project. It was obvious from the start that to conserve the tiger, a wide-ranging conservation program would be essential. And, from our first contacts, our mission has been to seek collaborative associations for program development, because ultimately it is the Russian scientists, agencies, resource managers, and local people who will decide the fate of their own natural resources. One of the goals of the Hornocker Wildlife Institute has been, and will continue to be, to provide leadership in initiating activities, relying heavily on Russian colleagues, transferring as much responsibility as possible to nationals, and providing training where appropriate and when requested. While the heart of our program continues to be scientific investigation, we have supported, directly and indirectly, a variety of programs aimed at conservation of the natural resources of the Russian Far East.

The Hornocker Wildlife Institute has finished more than three years of field study in the Russian Far East. Given the chaotic economic and political realities of working in Russia, we feel our achievements are substantial. We have fostered important ties with colleagues, institutions, and communities, and provided an important framework for initiating conservation activities. Below is a summary of accomplishments and activities.

RESEARCH ACTIVITIES

When examining the potential for research on solitary carnivores, one of their most important characteristics to consider is their secretive behavior. Although this is a behavioral adaptation to its predatory lifestyle, it makes scientific observations of many of their activities difficult, if not impossible, to document with reliability. Thus, one of the most useful tools for the study of carnivores is the radio-transmitter. In the case of carnivores, the transmitter is attached by means of a collar. With this radio-collar in place, study animals can be followed for two years or more, until the batteries no longer produce energy. To attach the radio-collar, researchers must temporarily capture animals and immobilize them with anesthetizing drugs so they can be handled safely. while the animal is immobilized, measurements are taken, the animal is generally examined, and the radio-collar attached before the animals is again released back to the wild. In addition, a small about of blood and tissue are taken from each captured animal. These samples are analyzed for genetic characteristics important to our understanding of how individuals are related to each other, and the diversity of the gene as it relates to conservation issues.

Once captured animals are released, to determine aspects of their ecology and biology, their movements are followed by following the signal from their radio-collars. In the Russian Far East, given the rugged landscape and the extensive movements of tigers, radio-telemetry tracking is performed most reliably through the use of aircraft. Whenever possible, however, closer tracking is performed to produce more specific information on tiger behaviors and activities. Below are descriptions of the activities and results of the field investigation, as well as our activities in the application of the information to issues important in the conservation of the Siberian tiger and the natural resources of the Russian Far East.

The primary study site for the Siberian Tiger Project has been, and continues to be, the Sikhote-Alin Biosphere Reserve. However, the Project also operates a smaller field research undertaking in and around Kedrovia Pad Reserve in the southern part of the Primorye Province (see Attachment 2). This southern project was originally designed to focus on tigers, with additional peripheral information to be generated on the endangered Amur leopard. However, early in 1995, this was reversed so that activities could emphasize Amur leopard ecology and conservation, with additional, peripheral information collected on tigers. This project is currently operated as the Amur Leopard Project, centered in the Kedrovia Pad Reserve (see Attachment 2), also under the direction of the Hornocker Wildlife Institute.

Trapping

Trapping is carried out in three types of situations: for re-capture of previously collared individual study animals, for resident individuals who are known to inhabit a particular area but are uncollared, and opportunistically in situations in which tigers have a good chance to be captured, but a full-scale trapping program is not been mounted. Under the umbrella of all three types, a total of nine tigers were captured. The only captures performed for re-collaring were completed through the use of a helicopter. This method is now considered the most efficient for re-capture of tigers for replacing radio-collars. Tigers 04, 03, 10, 08, 01, and 16 (in chronological capture order) were captured in this fashion. Capture programs aimed at particular resident individuals focused on three areas of the Sikhote-Alin Reserve and its extended area: Neevademka, Korima, and Sheptoon. Two male tigers were captured during these capture programs, one in Neevademka (tiger # 20) and one in Sheptoon (tiger # 22). Opportunistic capture was successful just one time, when a tiger kill was reported in the Sheptoon area. This lead to the capture of female #21.

The trapping of bears, both brown bears and Asiatic black bears, is unavoidable during ground trapping efforts for tigers; bears travel the same trails as tigers and often come to kills which have been made by tigers (where we often attempt to trap tigers). research on bears is considered important not only because of their interaction with tigers but also for developing conservation strategies for the bears themselves, both of which are of some conservation concern (due to poaching), in fact, the Asiatic black bear is considered a threatened species in Russia. Thus, radio-collars are placed on almost all bears captured by Project personnel. To date, the Project has trapped more bears than tigers, and during this reporting period added five bears to the study group.

<u>History and Status of Radio-Collared Tigers</u>

One of the main focuses of the Project has been to maintain radio contact with study animals, especially those which we have followed for a very long time, or who will provide information on aspects critical to the development of our conservation plan. During this reporting period, eleven tigers were radio-tracked and monitored. However, contact with two of these individuals was lost in the summer of 1995. These were two young male tigers who dispersed south of the Sikhote-Alin Reserve. The others are resident adults. The following are brief summaries of the activities of the radio-collared animals.

Tiger 01. Tiger 01 has been tracked since her original capture in February of 1992. Tiger 01's first litter consisted of one cub, in July of 1994. That cub's tracks were documented in July of 1995, but not later. The fate of this individual is unknown, however, it is possible that it dispersed and Tiger 01 bred again, since she was reported to have three cubs with her in the winter of 1995-1996; these reports were made by several hunters in the area. However, only two cubs were seen by Project personnel from a helicopter in March of 1996. Track size on the cubs traveling with Tiger 01 would indicate they were born sometime near 1 December 1995. Tiger 01 spent most of the late winter, 1996, in an area north of the Reserve, where wintering elk are known to congregate. She was in good condition when captured for re-collaring in March of 1996. She has been traveling more widely since then, as the prey have dispersed; but, she remains north of the Reserve.

Tiger 03. Tiger 03 was traveling with two cubs in spring of 1995, probably a male and a female. However, by October, only one cub could be confirmed with her, and in December she was in the company of Tiger 16 (a male), indicating the cub(s) had dispersed, or had been lost. Confirmation of the newest litter has not been made, but she continues to travel in her previously established and defined home range.

Tiger 04. In the summer of 1995, Tiger 04 localized her movements in the same area in which she raised her previous litter, suggesting to us that she had again given birth. This was confirmed with the first snows of 1995: tracks of one cub were found with her tracks. Since that time, Tiger 04 has remained confined to the northern portion of her previously defined home range. This area includes some land outside of the Sikhote-Alin Reserve. Our supposition at this time is that she has given up part of her area to a female cub from the previous litter. We hope to confirm this with trapping.

Tiger 15. Tiger 15 travels in the southeastern portion of the reserve. She is believed to have lost a litter of cubs in spring of 1995. In November, she was assumed to have produced a cub through a mating (documented through telemetry and observation) with Tiger 16. She was lactating when captured in December. She confined her movements to a remote valley in winter, but was confirmed to be traveling with a cub in April of this year. Her association with Tiger 16 again in Summer of 1996 brings some suspicion about the fate of her cub; but, tracks of a small tiger in the area have been cause for even more speculation about the possible mating while the cub is still in the area.

Tiger 16. Tiger 16, an adult male, continues to travel in an area almost identical to that of Tiger 15. This amount of overlap with only one adult female, and the smaller male home range in relation to other studies of big cat dynamics have been cause for additional speculation for the Project. However, Tiger 16 has shown very little home range overlap with the male to the west, a relatively standard scenario for large cats.

Tigers 18 and 19. Tigers 18 and 19 are sibling males who left their natal area in the southern part of the Sikhote-Alin Reserve and dispersed south. This is a normal pattern for solitary cats: males normally disperse farther than their female counterparts. However, we have not been able to track these two individuals consistently. Their last locations were obtained in the summer of 1995, despite extensive aerial searches.

Tiger 20. Tiger 20, in contrast to Tiger 16, has a home range that overlaps with at least three adult females: Tiger 03, Tiger 21, and Tiger 18 and 19's mother (as yet uncollared). As yet, his number of locations are too few to obtain a good home range estimate of area, but it is very apparent that his home range is substantially larger than that of Tiger 16, his smaller and younger neighbor. The adjacent home ranges of Tigers 16 and 20 are providing valuable data on social structure of the male portion of the population.

Tiger 21. Tiger 21, like Tiger 01 on the northern edge of the Sikhote-Alin Reserve, lives almost entirely outside the boundaries of the Reserve. this provides valuable comparative date for the Project. For instance, although her home range is comparable in size to the other tigers, there are portions of the home range that incur high human use (roads, logging, hunting, etc.) that appear to be avoided by this tiger. No reproductive activity has been recorded yet for Tiger 21, although she is an adult.

Tiger 22. Tiger 22 is the most recent addition to the Project. He is a young adult male tiger, and we assume his subsequent locations will define him as the resident male in the Sheptune drainage, completing an important part of the social organization matrix for the Project on the southern end of the Sikhote-Alin Reserve.

Food Habits

A critical component of characterizing the natural history of any predator is documentation of the relationship between it and its prey. The most easily obtained information in this area is food habits: what does the animal eat? Over the duration of the project, more that two-hundred kills made by tigers have been documented, more than thirty of those during this reporting period. The dominant items in the kills made by tigers continue to be elk and wild boar. Elk make up slightly more than half of the animals found killed by tigers, while boar make up approximately one-third of those prey.

Our attempts to document distribution and abundance of prey during this reporting period were thwarted by bad weather and lack of aircraft. However, our census data from the previous winter of 1994-1995 indicated that prey numbers outside of the Reserve were several-fold lower than those measured inside the Reserve.

Habitat Analysis

One of the key components of the STP has been the aspect of technology transfer, one of the key components of our research and conservation efforts with tigers is habitat utilization analysis. These are combined in the Geographic Information System Laboratory at the SAR. The Project has created a state-of-the-art GIS which will provide the essence of habitat characterization for tigers. We have provided two GIS laboratory technicians with continuous location data on tigers for input and analysis of territory size. However, more importantly, these Russian technicians have also been inputting the vegetation map for the reserve. This process is complete (or nearly so at the time of this report) and will allow us to proceed with our number on priority, analysis of habitat use by radio-outfitted study animals. It also will allow us to apply this information to landscape-scale analysis in the Conservation Planning part of the overall program (see section below).

Space Use and Social Organization

The documentation of tiger movements and use of specific areas is a primary focus of the Project. Such data is critical in developing an understanding of "tiger society" and developing conservation plans for the species. For instance, how much area do individual tigers require? How is the size of the area affected by habitat quality, or prey densities, or human use? The answers to these questions can be used in land use planning and integrated conservation plans (see Conservation Planning section below). The Project is currently monitoring seven resident adult tigers in the study area, two males and five females. Attempts are made to locate each animal at lease once per week, through aerial or ground-based radio-tracking. Through the analysis of these location, we have determined that each tiger utilizes approximately 300 to 400 square kilometers. These area generally exclude tigers of the same sex, but often extensively overlap with the areas used by tigers of the opposite sex. We have found little, if any, definable difference between the size of the area used by male tigers versus the size of area used by females tigers. These area and specific tiger locations will be further analyzed to document the habitat types which tigers select for, another critical element in conservation planning.

In addition to area (or territory) and habitat analysis, telemetry locations allow documentation of interactions between individuals (for mating, for example), of tiger deaths that may occur, and the dispersal of young from their mother and her home areas, or territory. The latter information is particularly difficult to obtain, and very important to our understanding of tiger social organization and the development of conservation plans. Much like what is known for other big cats, young tigers leave their mothers at approximately one and one-half years of age. To date, the Project has only been able to document the dispersal of four tigers, and none of these have been tracked through dispersal to the time the young tigers establish home areas of their own. The trapping and tracking of the tiger families currently being followed (see above History and Statue section) will be an important focus in the coming year.

CONSERVATION PLANNING

One of the most important activities of the Project has been conservation planning. This activity was formally begun in 1995 when two characteristics of the Project were aligned to make this possible, and productive: the data base was at a point where reasonable conservation measures could be derived from it, and our field coordinator for the first three years of the Project, Dale Miquelle, was contracted through the Hornocker Wildlife Institute to oversee the biodiversity component of the USAID Environmental Policy and Technology (EPT) Project in the Russian Far East. This position on the EPT Project allowed the Siberian Tiger Project the perfect conduit for injecting sound conservation proposals (based on our data), and it allowed easier access to levels of local and regional government agencies responsible for policy decisions.

The centerpiece for our conservation planning component has been the document, A Habitat Protection Plan for the Amur Tiger, produced by the Siberian Tiger Project early in this reporting period. This document (see Attachment 3) is a preliminary attempt to apply known, soundly collected biological information about the Siberian tiger to a range-wide conservation program. Two principal components were used in the development of this preliminary document: information from the field study in the Sikhote-Alin Reserve and a range-wide analysis of habitats, tiger distribution, and human activities in Primorye Province and southern Khabarovsk Province (the political definitions in which tigers are found in the Russian Far East). This latter component was undertaken as an offshoot of our previously established GIS capabilities for the Siberian Tiger Project in the town of Terney, center for our activities on the Siberian Tiger Project. Established in 1994, this GIS center has been inputting tiger telemetry data along with physical and biological characteristics of the areas these tigers are using. This will provide the tools for determining just what features are most important to tigers. In 1995, under the Conservation Planning component of the Siberian Tiger Project, this analysis was expanded.

Early in this reporting period, the USAID EPT Project again came to the Siberian Tiger Project for expertise, this time for developing their data base for natural resource planning and development. At that time, our GIS coordinator, Troy Merrill, was also subcontracted through the Hornocker Wildlife Institute to assist in the development of computer-based maps for the region. Under the aspices of the EPT project, in cooperation with the Siberian Tiger Project, range-wide analyses of tiger distribution and requirements were made. This included a regional assessment of biological diversity, a comparison of the conservation paradigms which could be applied to the region (see Publications and Presentations, below), and a variety of maps for conservation planning purposes which depict vegetation and physical features important to tigers (see Attachment 4). This overall planning, along with the further development and refinement of the Habitat Protection Plan, continues to drive the Conservation Planning portion of the Siberian Tiger Project.

ENVIRONMENTAL EDUCATION

The environmental education component of the Siberian Tiger Project was initiated during the current reporting period. Although the Project had undertaken a variety of activities in previous years which were certainly centered on environmental education - mostly focused on tigers - this was the first period in which formalized, directed activities and programs were attempted. Focal groups for which the programs were directed were divided into three identifiable social groups: the general public, school children, and hunters. The first target, the general public, was assessed early on for methods which could have impact. We identified four outlets for information which seemed to be prevalent throughout Russian society in the Russian Far East: radio, television, wall calendars. Since we did not have the resources or expertise to produce radio or television programs at the time, we focused immediately on the development of a striking calendar for distribution in 1996. Calendars are almost omnipresent in the Russian Far East. Even very old calendars are kept on walls for decoration for many years if they have an attractive scene; this is true not only in offices in Vladivostok, but also in cabins in the forest and small towns on the coast. Thus, our goal was to produce something with a picture and a saying which could endure for years, with a tiger focus. After consultation with several of our Russian colleagues, we chose the saying, "protect the jewels of the Russian forest", printed with a picture of two tigers (see Attachment 5). The final product has been distributed in Russia and is considered a major success. Still, wherever we go, people want them, if they are not already on the wall. They have been very popular. Another product that the Project distributed was a bumper sticker (see Attachment XXX). This was in response to the obvious use of English-slogan stickers in the metropolitan areas.

The exact approaches necessary for obtaining the highest level of impact on the other two education groups (school children and hunters) required the Siberian Tiger Project to enlist additional expertise in planning. Thus, in January of 1996, Dr. Samuel Ham, from the Resource Recreation and Tourism Department at the University of Idaho was brought to the Russian Far East to assess the needs and suggest approaches to develop programs for these two groups. Dr. Ham met with groups and individuals in Vladivostok and Terney, and developed a prospectus report (see Attachment 6) which is currently being used in the development of additional proposals, funding, and programs.

Also as part of the environmental education program, we developed a small art exchange. Funding for art materials was provided for school children in both Terney, Russia, and Moscow, Idaho, to paint work under the general theme, "the nature of our world." Students were encouraged to paint aspects of the natural history of the area near Terney, and the area near Moscow. Thus, paintings produced included such things as elk, deer, eagles, and, of course tigers. The American pieces were then transported to Terney, where they were put in a combined show with the Russian pieces in early 1996. In spring of 1996, the entire show was shipped to the United States, where it was displayed in the Student Union Building of the University of Idaho, a grade school in Pullman, Washington, and also at the Omaha Zoo, in Omaha, Nebraska. The program was a great success of good will and education of not only the school children involved, but the parents and the general public that saw the show.

Three additional activities were conducted under the environmental education program. First, we were able to provide a small amount of support to the Peace Corps volunteers in Terney for their programs. The Terney Peace Corps program was specifically established to focus on environmental education. One of the activities which the program developed was an environmental resource room at the Sikhote-Alin Reserve. This room will be a clearing house for materials in environmental education, including a computer for development of source materials and environmental education games. The Siberian Tiger Project supported the transportation of computer materials from the United States for the development of the room. In addition, the Siberian Tiger Project provided funding for the inclusion in the field work of two students from Moscow University in Moscow, Russia. These students were instrumental in activities of the field operations during the summer months, and were given small, identifiable portions of the project which they could use to develop research reports for their university work. Finally, filming was completed during this reporting period of a documentary on the Siberian Tiger Project which was produced by the National Geographic Society and will air on NBC sometime in 1997.

PUBLICATIONS AND PRESENTATIONS

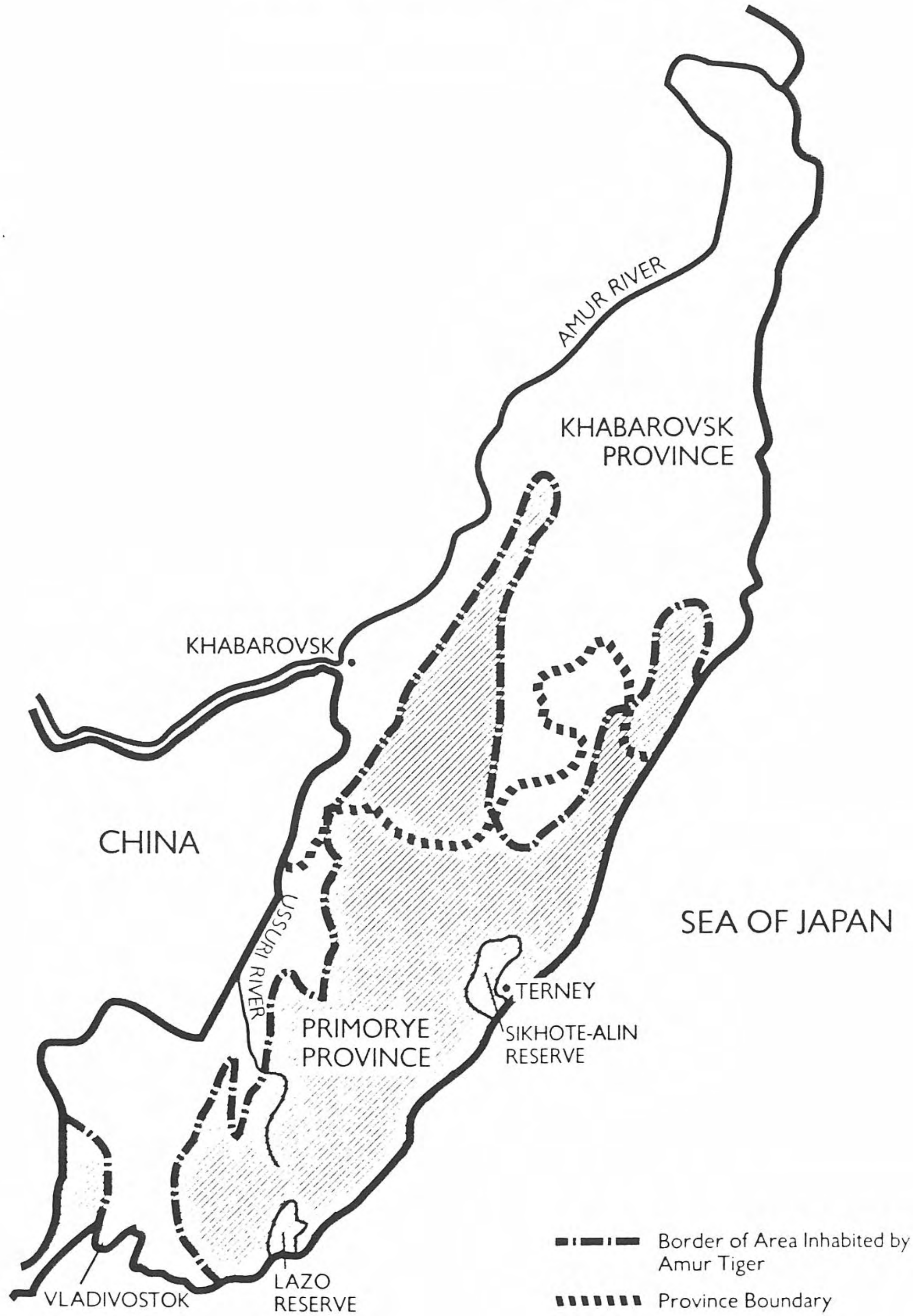
A Conservation Prospectus on the Amur Tiger. November 1995. Presentation to the Special Meeting of the Amur Tiger EEP in Moscow, Russia.

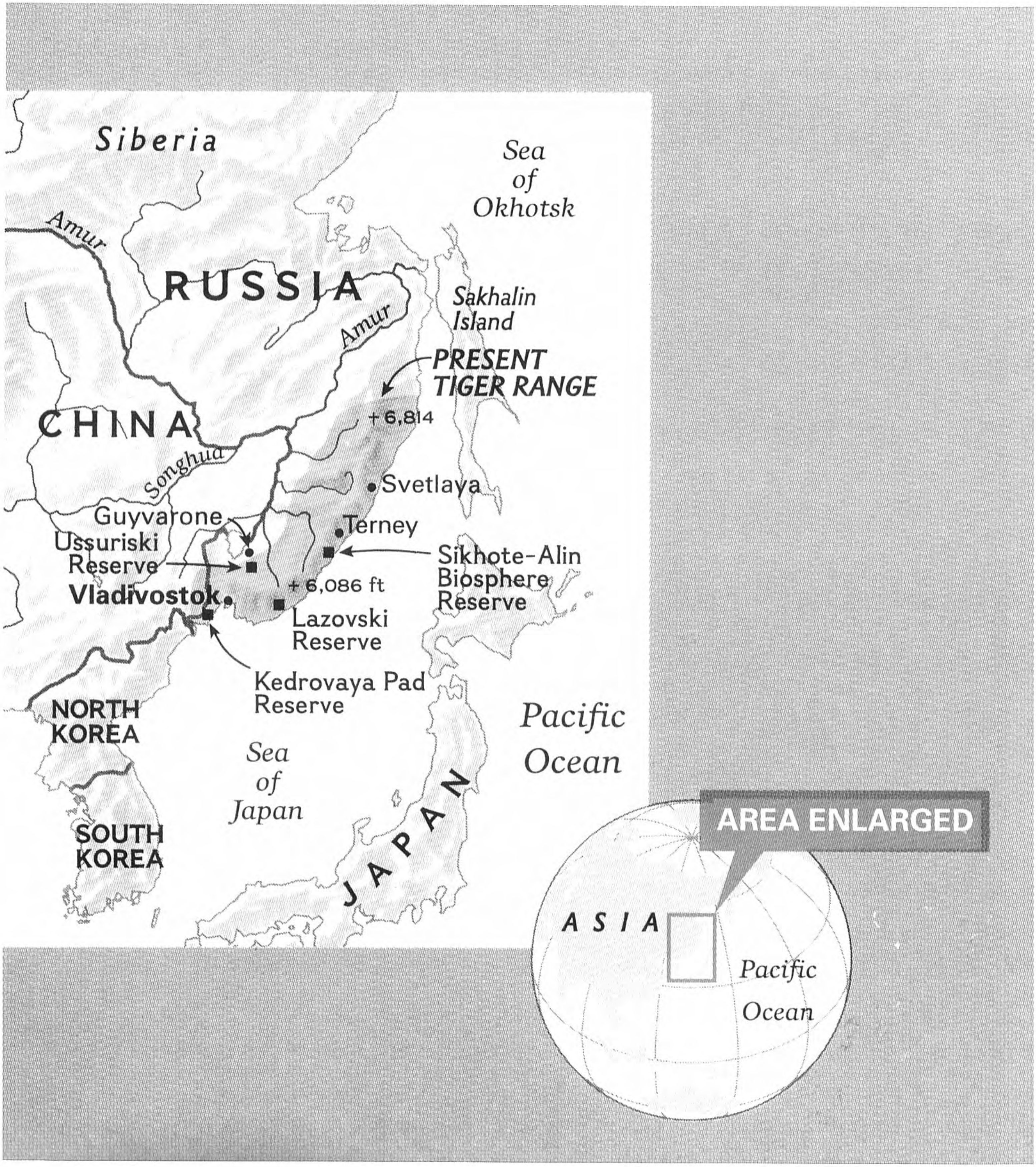
Hot Spots, Umbrella Species, and Indigenous People: the Siberian Tiger as a Conservation Paradigm. June 1995. Presentation to 1995 annual conference of the Society for Conservation Biology in Colorado Springs, Colorado.

Development of a Habitat Protection Plan for the Siberian Tiger. June 1996. Presentation to the 1996 annual conference of the Society for Conservation Biology in Providence, Rhode Island.

Food Habitat of Amur Tigers in Sikhote-Alin Zapovednik and the Russian Far East, and Implications for Conservation. Publication in press in the Journal of Wildlife Research. (see Attachment 7).

FIG. 1. DISTRIBUTION OF AMUR TIGERS IN RUSSIAN FAR EAST

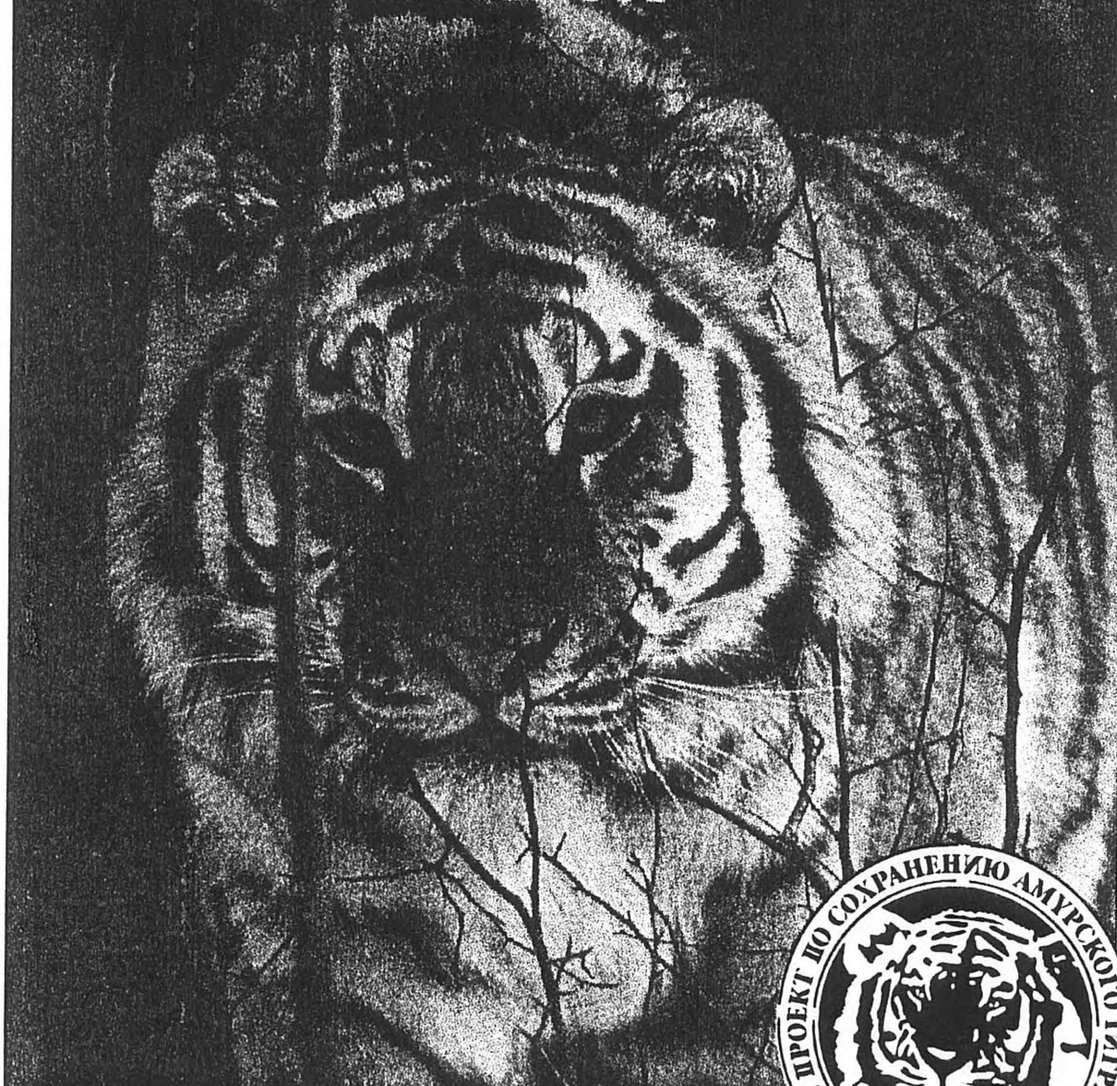




Siberia
Sea of Okhotsk
Amur
RUSSIA
Amur
Sakhalin Island
PRESENT TIGER RANGE
CHINA
+6,814
Songhua
Svetlaya
Guyvarone
Terney
Ussuriski Reserve
Sikhote-Alin Biosphere Reserve
+6,086 ft
Vladivostok
Lazovski Reserve
Kedrovaya Pad Reserve
Pacific Ocean
NORTH KOREA
Sea of Japan
JAPAN
SOUTH KOREA
AREA ENLARGED
ASIA
Pacific Ocean

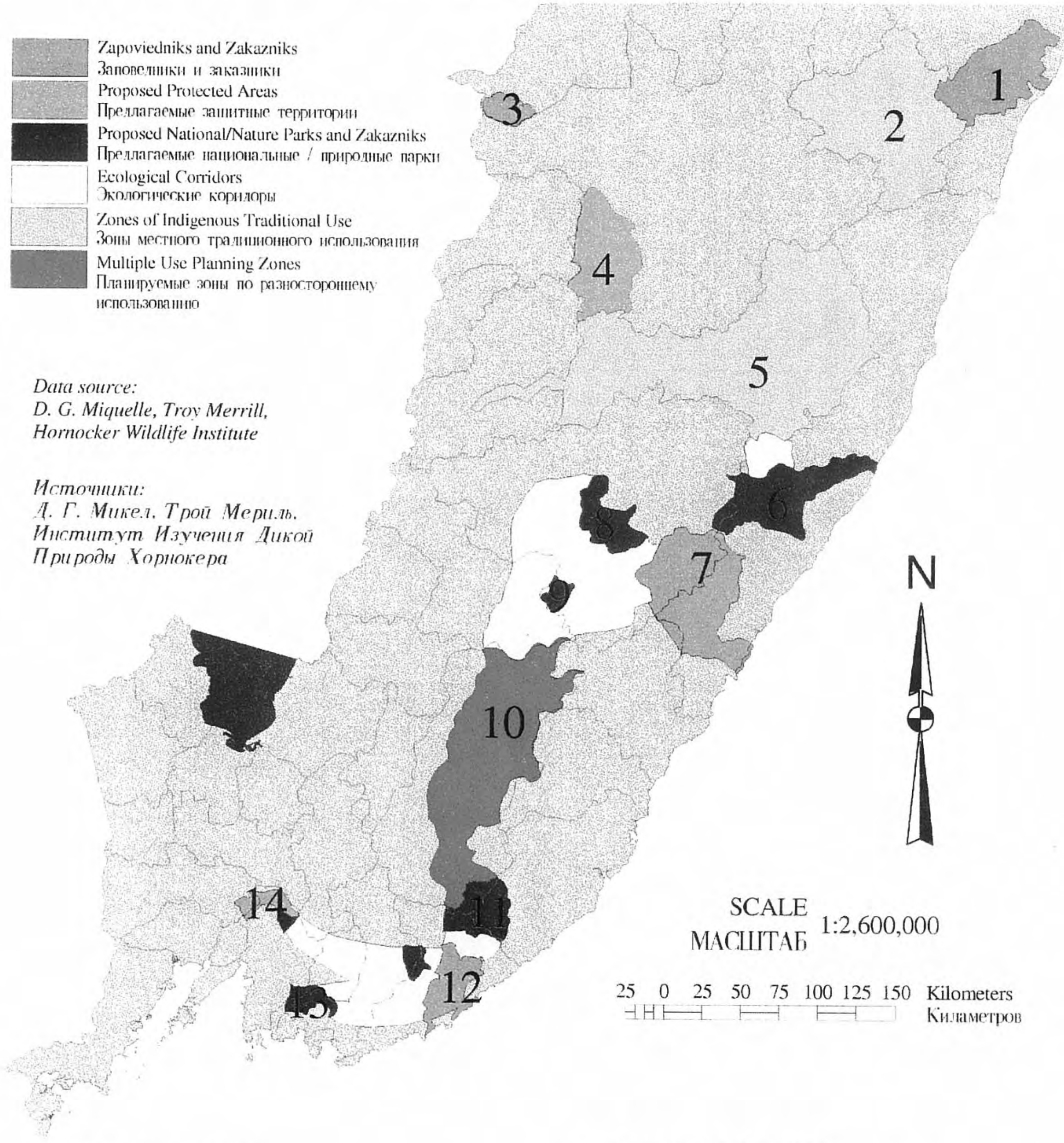
A HABITAT PROTECTION PLAN FOR AMUR TIGER CONSERVATION

ПЛАН ЗЕМЛЕПОЛЬЗОВАНИЯ С ЦЕЛЬЮ СОХРАНЕНИЯ АМУРСКОГО ТИГРА



ПРОЕКТ ПО СОХРАНЕНИЮ АМУРСКОГО ТИГРА
SIBERIAN TIGER PROJECT

AMUR TIGER CONSERVATION PLAN
Network of Core Areas
ПЛАН ПО СОХРАНЕНИЮ АМУРСКОГО ТИГРА
Сеть защитных територий



1. Botchinski Zapoviednik
   Бочинский заповедник
2. Samarga Region of Traditional Use
   Зона традиционного пользования в районе Самарги
3. Bolsheketerski Zapoviednik
   Большекетерский Заповедник
4. Matei Zakaznik
   Заказник в районе Матей
5. Bikin Region of Traditional Use
   Зона традиционного пользования в районе Бикин
6. Kema-Amgy National Park
   Кема - Амгу Национальный Парк
7. Sikhote-Alin State Biosphere Reserve
   Сихоте - Алинский Государственный Биосферный Заповедник
8. Central Ussurisk National Park
   Средне - Уссурийский Национальный Парк
9. Taeschnie Zakaznik
   Таежный Заказник
10. Chuguevski Multiple Use Area
    Чугуевская зона множественного пользования
11. Upper Ussurisk National Park
    Верхне - Уссурийский Национальный Парк
12. Lazovsky State Zapoviednik
    Лазовский Государственный Заповедник
13. Southern Primorye Nature Park
    Южно - Приморский Природный Парк
14. Ussuriski Zapoviednik
    Уссурийский Заповедник

AMUR TIGER CONSERVATION PLAN

STEP 1

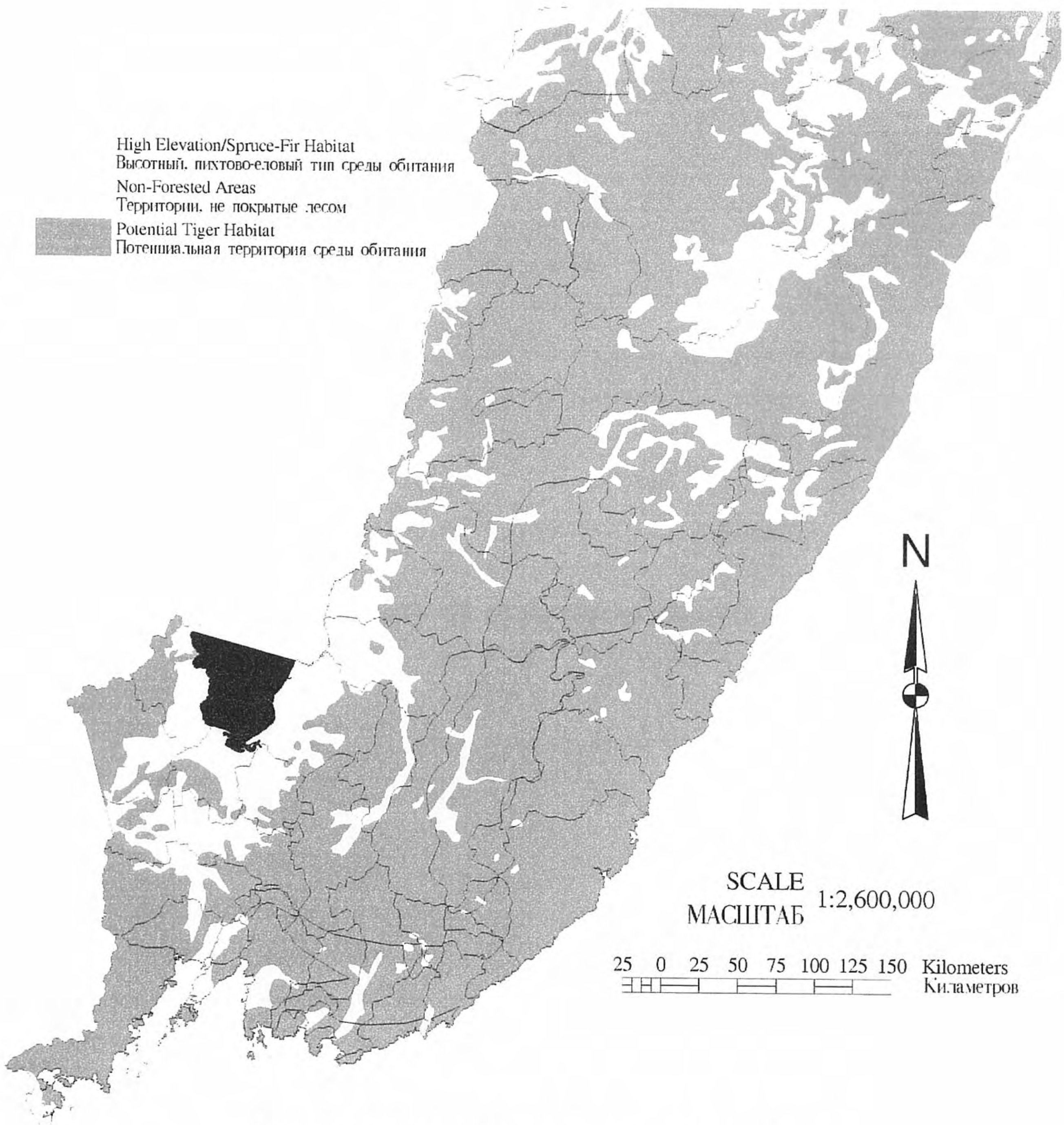
Existing State Reserves

8729 Km2

19 to 21 Female Tigers Within Conservation Area

POTENTIAL TIGER HABITATS

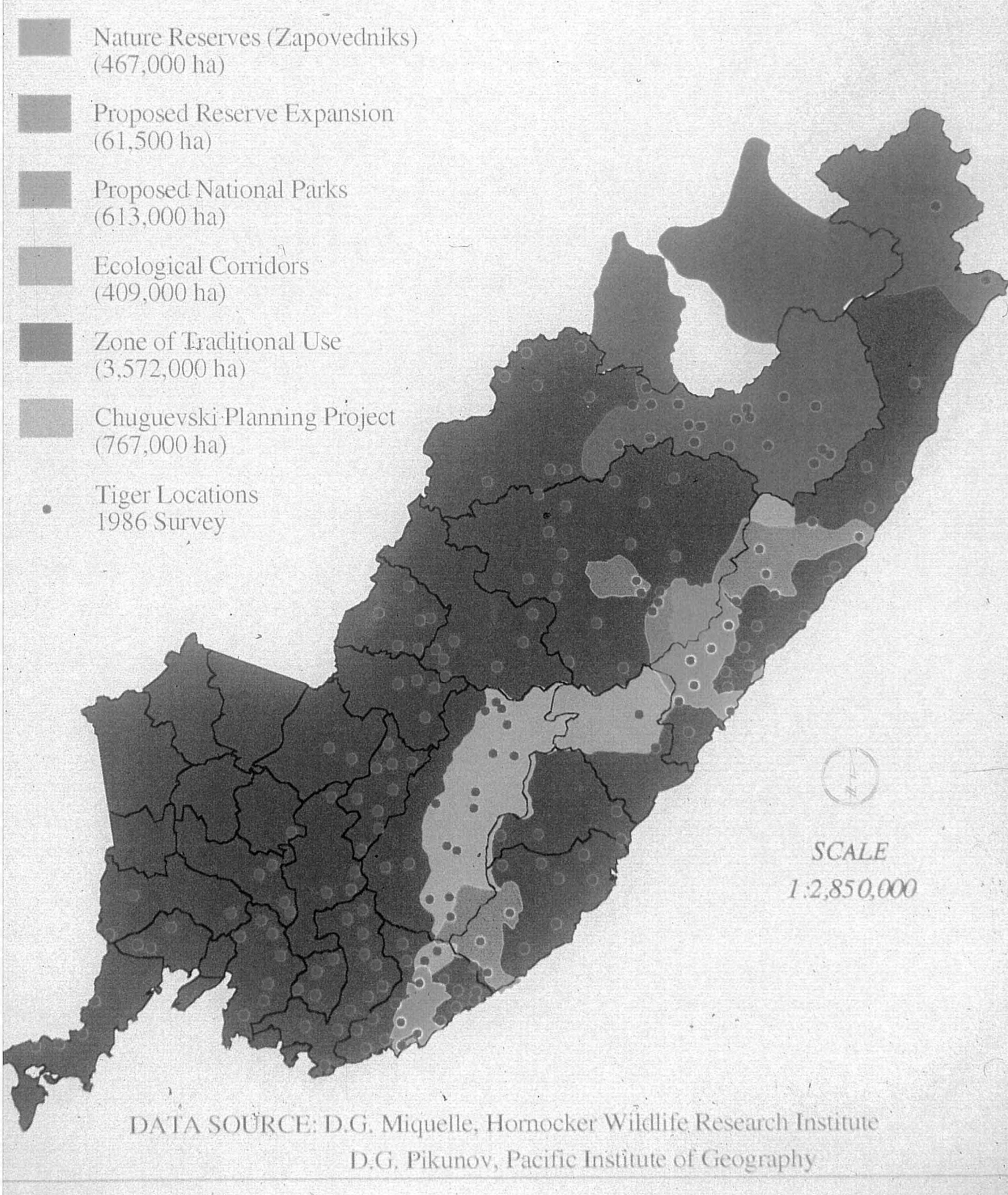
ПОТЕНЦИАЛЬНАЯ ТЕРРИТОРИЯ СРЕДЫ ОБИТАНИЯ ТИГРА



Data source: D. G. Miquelle, Troy Merrill, Hornocker Wildlife Institute

Источники: Д. Г. Микел, Трой Мериль, Институт Изучения Дикой Природы Хорнокера

AMUR TIGER CONSERVATION PLAN
Network of Connected Core Areas



DATA SOURCE: D.G. Miquelle, Hornocker Wildlife Research Institute
D.G. Pikunov, Pacific Institute of Geography

Сбережём богатства российской тайги!

январь

П	В	С	Ч	П	С	В
1	2	3	4	5	6	7
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15	16	17	18	19	20	21
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1996

Protect the Siberian Tiger

Observations and Recommendations for Formal and Nonformal Environmental Education Related to HWI's Siberian Tiger Project

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Observations and Recommendations for Formal and Nonformal Environmental Education Related to HWI's Siberian Tiger Project

Submitted to Hornocker Wildlife Institute by Sam H. Ham, Consultant, February 10, 1996

During my trip, I formed a number of impressions about possible future directions for environmental education (EE) within the Tiger Project. Although it is important to remember that my exposure to the Russian Far East was brief, what follows is an attempt to summarize what I consider my most important observations about the current status and possible future directions for EE in the Project. Observations are discussed in some detail in order to give you a clear idea of where each recommendation comes from. Recommendations follow each observation. First, a series of executive or overall recommendations is offered with respect to the role HWI and the Project might adopt in formal and nonformal EE related to the tiger. Second, a list of complementary observations and specific recommended actions is offered.

Overall Observations

- The Russian and international conservation communities recognize that the Siberian Tiger is in grave danger of extinction. As a result, many organizations (domestic, foreign, public and private) have involved themselves in the important work of trying to save the tiger. Undoubtedly, the number of "players" will grow even further as visibility of the work of currently-involved organizations expands. Most, if not all, of these organizations have some type of environmental education (EE) focus. Coordination seems necessary. To the extent EE efforts compete, conflict or duplicate one another, their ability to contribute to tiger conservation will be impeded.

- EE efforts related to the tiger are currently underway both in formal EE (defined as regular academic programs delivered within the mandated school curriculum) and nonformal EE (which generally focuses on non-academic audiences, or if school-based, on non-academic extracurricular activities). Based on my discussions and admittedly limited observations, it was my impression that, of the two, formal EE is receiving the lion's share (tiger's share?) of attention in the Russian Far East. Although some individuals (e.g., Vaisal Sulkin and his wife) are doing impressive work in the nonformal sector, attention to non-academic audiences seems, on the whole, comparatively limited. Since the *immediate* threats to tiger well-being stem primarily from poaching and habitat destruction (actions generally attributable to audiences found outside the K-12 structure), education and communication efforts aimed at *those* audiences seem urgently needed--not as a substitute for formal EE programs, but as an important supplement. Given the geographic and social reality of the Russian Far East, stabilization of the tiger population will require a successful biologically-based management strategy carried out in concert with an enlightened and supportive public. Because of the tiger's predicament, "enlightenment and support" cannot wait for the next generation when today's school children have grown to adulthood. Clearly, key audiences (largely adult and largely outside the formal state education system) must be given at least equal priority in the short- and mid-term.

- Formal EE seems in good hands in the Russian Far East. My brief exposure to Russian Far Easterners gave me the impression that they are highly educated as a people, at least in technical areas. Education is important to them and they seem to have a well-conceived system for training and certifying professional educators. The people I met who were working in formal EE seemed obviously competent both theoretically and methodologically. Although, I personally believe they focus too much (exclusively, it seems) on science and geography applications, and that they need to be careful to avoid EE becoming associated (or synonymous) with only game-like instructional methods, they seem to be addressing the right questions and trying to build instructional programs on a foundation of good information. Even more important, they are *Russians*, and no one is better prepared nor politically more acceptable to environmentalize the Russian school curriculum. For these reasons, I feel the Project stands to make its biggest contribution to formal EE by (1) morally supporting and applauding the efforts of these people (e.g., Olga Green & WWF/Germany, ISAR, individual teachers like Galina and Luba, and PCVs Chris and Michael in Terney), (2) by making sure they are kept up to date on issues pertinent to the tiger, (3) by leveraging or buying exposure for the tiger in the materials and programs they develop, and (4) by generally doing what it can to augment their work without heavy financial commitment. Since any society is predictably (and justifiably) protective of its education system from foreign influences, HWI and the Project should expect to be a relatively silent partner in most formal EE efforts--even if it sometimes means providing human or financial resources without visibility.

Summary Recommendation for the Project's Role in Formal and Nonformal EE

Based on the foregoing observations and impressions, I want to offer the following three recommendations as an aid to HWI in defining its role with respect to EE in the Siberian Tiger Project. The recommendations are intended more or less as a three-point policy to assist the HWI in prioritizing its actions, developing partnerships, and allocating and raising funds for EE related to the Tiger Project.

Emphasis on formal versus nonformal EE: The Project should continue to support and coordinate with ongoing and future programs in formal EE, but it should focus its attention and limited resources on nonformal EE efforts.

Agenda for formal EE: The Project's primary role in formal EE should involve (1) providing wherever possible in-kind assistance for teacher training programs, and (2) providing small-scale financial contributions (generally in exchange for tiger issue visibility) toward the development of teaching resources, particularly those that could be used in subject areas outside of geography and science.

Agenda for nonformal EE: In the short-term (next 1-5 years), the priority audiences for nonformal EE would seem to be hunters and future hunters.

Complementary Observations and Suggested Actions

Observation 1: Current formal environmental education efforts focus heavily on science and geography but relatively little, if any, EE is taught outside of these subject areas. Without exception, every person I met with who was involved in formal EE came from a science or geography background. It appeared to me that EE was well taken care of in these curricular areas but that efforts were not underway to bring an environmental dimension into history, literature, art, social studies, mathematics, physical education, Russian and other curricular areas.

Recommendation 1: EE needs to branch out more liberally throughout the curriculum. Implications for the Tiger Project are to take an active role in recruiting and nurturing relationships with non-science/geography teachers and to look for ways to expand the influence of school-based tiger education efforts by supporting development of materials appropriate and useful for teachers in the broadest range of curricular areas, not just science and geography. See, for example, recommendation 8. (*Time frame: immediate to end-of-project.)*

Observation 2: Current nonformal EE efforts focus on developing awareness and identity of the Tiger Project through distribution of information (primarily printed materials) to a broad general public. This is important to maintain and perhaps even broaden as competition for the trust of locals (and for limited funds) intensifies among a growing number of institutions. The Project has recognized, however, that more specific audiences exist, especially *hunters*, who might be targeted by nonformal EE efforts. The Project seems well positioned (more so than other organizations currently working in the region) to launch communication efforts that specifically target this audience.

Recommendation 2: The Project should intensify efforts to expand nonformal EE efforts aimed at hunters and future hunters (see also recommendation 3 below). Approaches and materials developed to reach these audiences should remain useful beyond the life of the Project, and attention should be given leaving a cadre of Russians (ideally hunters, themselves) trained and capable of continuing EE program development. (*Time frame: immediate to end-of-project.)*

Observation 3: Hunters are a difficult audience, in part because their behaviors are strongly tied to a gender identity, and in part because they are ostensibly a relatively "closed" group. For communication purposes, "hunters" may be defined broadly in two categories, *current hunters* and *future hunters*, each of which is reachable differently in both time and space and with different media, information content and communication approaches.

Recommendation 3: Since future hunters consist primarily of school-aged boys, appropriate nonformal EE activities and materials should target males aged 6-17. Two possibilities emerged during discussions: (1) A "Hunters' Club" could be started at each local school. During club meetings and outings, a number of topics could be taught (e.g., hunting ethics, wildlife values, natural history, tracking, gun safety, outdoor skills, biological research methods, basic veterinary techniques, and a variety of other topics. By design, tiger conservation and an anti-poaching ethic could be made integral to this type of program. (2) A second idea might be to start a Scouts-type program with a system of merit badges, ranks and the public service tradition inherent in scouting programs all over the world. As in other countries, indoctrination into the scouting "family" could include a conspicuous environmental and outdoor ethic. Depending on local interests and cultural preferences, a hybrid of ideas 1 and 2 might be more acceptable. *(Time frame: 1 to 2 years to establish initial program.)*

Observation 4: In designing EE programs for both current and future hunters, the choice of communication appeal (i.e., the design and content of a message intended to persuade) is a critical decision. Experience shows that messages judged to be persuasive by environmental educators are not likely to be so persuasive to nontechnical audiences primarily because of differences in the backgrounds and interests of the two groups. As in the U.S., most Russians involved in EE (both formal and nonformal) reportedly come from a life sciences or geography tradition. Understandably (though there are exceptions), they seem to stress scientific inference and logic as the primary routes to mass persuasion. Research shows, however, that other routes to persuasion (those relying on affective responses such as love, hate, respect, fear, pride, nationalism, etc.) may be superior for lay audiences when used alone or in combination with appeals to logic and scientific reasoning.

Recommendation 4: Although more needs to be learned about the audiences (see recommendation 10), two affect-based communication vehicles seem well-suited to the Russian Far East: (1) *Pride:* Messages might appeal to national, regional and ethnic pride in the fact that the Siberian Tiger exists only in the Russian Far East, and that Russians, Vladivostokians, Terneyians, etc. are famous throughout the world because they have not yet exterminated the tiger. This appeal is already apparent in some nonformal programs (e.g., Vaisal's video, *Who's Boss of the Taiga?*) and came up in a few discussions in Vladivostok and Terney. Notably, it is also cited as a primary strategy in the National Biodiversity Conservation Strategy recently completed by the government of Bulgaria in collaboration with WWF, TNC WRI and USAID. (2) *Responsibility:* Messages might appeal to hunters' moral and ethical responsibility to preserve the tiger who, like the hunter himself, is a symbol of the wilderness and the wild. Although I have less insight into this one, the idea it seems is that there is a tradition among "true" hunters (as Picovich sp?? put it) that both they and the tiger symbolize what is good and pure (and perhaps manly) about wild country. Is this a Daniel Boone primitivist notion (i.e., that a man's self-worth increases proportionately with the degree of contact he has with raw nature?, If such a tradition exists, appealing to hunters to let tigers live might link the hunter's image with that of the tiger--the survival of both of them is on the line, etc.; together they can remain or together they can pass to the history books. Although this vehicle seems to contradict the other more prevailing notion of hunters as a group of unprincipled killers in search of money, meat and evil entertainment, to the extent some hunters (perhaps Picovich's "true" hunters) exist, they might respond to such an appeal. (*Time frame: immediate to end-of-project.*)

Observation 5: While it is clear that Russians like printed materials containing words in English, this does not mean that those words convey anything about the environment in a convincing or persuasive way. In fact, my experience in some Latin American countries has been that some people reject environmental conservation not because they are actually at odds with its goals, but because US-based donor logos and titles are on so many of the printed materials available, they become inextricably linked in some people's minds with foreign influence in their country. True, the reaction is borderline xenophobic, but I also believe it is a normal response, especially if the US is involved (as you know, we are often perceived as untrustworthy and the root of all troubles). While I have no evidence from my brief stay to comment one way or the other on the Russian Far East, I want only to remind you (as I do USAID, Peace Corps, etc. in other countries) simply to be mindful of this. It is natural to want to be visible, especially when we've put our money into something we care deeply about. But because of source credibility factors, when foreigners are perceived to be behind a persuasive communication attempt, mistrust--even of a message that would otherwise be completely acceptable--can undermine the effort. At times, playing the silent partner--ah, the anonymous philanthropist--is the best strategy if we want our message to be accepted and internalized by a foreign audience. It must be perceived as "theirs."

Recommendation 5: Try when possible (and it is often *not*) to keep HWI's public relations materials (calendars, bumper stickers, etc.) separate in the public's eye from any EE programs you may be involved in. In the former, your logo, affiliation with the UI, foreign ownership, etc. are obviously just fine. Clearly, the Russians *love* the materials you produce and they are grateful to have them. In a comparative sense, however, I would recommend downplaying your up front involvement in such efforts as *Zov Taigi* articles, other printed educational materials such as classroom activity guides, etc., and in radio and TV programs that may be produced and aired in the coming years. By "downplaying," I am not implying that HWI should never receive credit. On the contrary, you *must* maintain visibility within the Russian conservation community, but not necessarily in the eyes of the intended audience. In some cases, perhaps acknowledgment could be as subtle as a simple "thanks" rather than a full disclosure of your affiliation. Interestingly, I think WWF has been able to avoid some of this problem by adopting a logo sporting an innocuous and widely-recognized international symbol and by perpetuating the notion that each country program operates independently of foreign influences. Nothing could be farther from the truth, but that is the prevailing belief, no? Enough said here; my recommendation is simply to remain cognizant of xenophobics. They're everywhere, and your work is too important to forget it. *(Time frame: immediate to end-of-project.)*

Observation 6: In my interviews and meetings, I usually asked about community events such as fairs, founder's day celebrations, international Earth Day, and similar events. My purpose was first to find out whether the tradition of community wide celebrations exists in the Russian Far East, and second to inquire about the acceptability of using such events as a forum for advancing community-level education about the tiger. Results were mixed. Some people said, "Yeah, we have celebrations." Others said, "No, we don't have them." When I asked whether such celebrations might be a useful way to disseminate information about the tiger, virtually everyone answered yes. I wasn't entirely convinced, but capitalizing on whatever tradition of community celebrations currently exists might be a good way to improve and expand awareness about the tiger in local communities.

Recommendation 6: Where feasible, the Project should try to capitalize on regular community celebrations as a mechanism to build local awareness and support of the Project and to disseminate information about the tiger and tiger conservation. Where communities are receptive to the idea but do not already have such a tradition, the Project might work with a local steering committee to create an annual Tiger Day Celebration. In preparing for such events, the Project might want to develop a small portable exhibit, a standardized slide talk or AV program, a video, and perhaps a collection of "touchables" such as track molds, bones, etc. (if such things exist) that could be displayed on a table. A portable cassette player and John's and Linda's tape of tiger sounds could likewise be useful. Once developed, these materials could be used in a wide variety of other situations. *(Time frame: 1 year to end-of-project.)*

Observation 7: Vaisal Sulkin is an unusually talented communicator and environmental educator. I recommend involving him in the creative aspects of EE projects whenever you can afford him.

Regarding his request for $1200-1500 per year for a two-page spread in *Zov Taigi*, you can't afford not to be in the magazine. It's the only game in town, and he and his wife do a great job researching, writing and producing it. However, I would offer him the high end and tell him that you need not only the two magazine pages but a regular "Tiger Update" (30-60 seconds) on *each* of his TV shows in the future.

Recommendation 7: The Project should use its purchase of the two-page spread in *Zov Taigi* to leverage a regular "Tiger Update" report in each TV program Vaisal Sulkin produces in the coming year. Each report would update viewers on any new research findings, news of poaching or poachers apprehended, cubs born, and similar items. The main purpose of the updates would simply be to keep the importance of tiger conservation in the public's eye. *(Time frame: 6 months to 1 year.)*

Observation 8: I am not sure whether school competitions are as popular in Russia as they are elsewhere. But according to someone I talked to (I can't decipher my notes!) contests within schools and possibly even between schools might be effective vehicles for expanding awareness of the tiger. In my experience, public speaking competitions and art contests have been especially useful in environmental education. An annual speaking competition among secondary students could be devised in which students are given a specific topic related to the tiger (tiger ecology, threats to tigers, tigers and people, etc.) and told to prepare speeches of a required length. Parents, teachers, community leaders, journalists and others are invited for an evening of presentations by the students. Judges select winners who become finalists for a regional competition. Ideally, there would be ample press coverage. Art contests would be similar except organizers might want to specify the category of art (water paintings, acrylics, collage, sculpture, jewelry, etc., that should be produced. The public is invited to a gallery show of the students' creations. Again, ample press coverage would be important. The idea of these competitions is to help students develop their artistic talents and public speaking skills at the same time drawing community wide attention to the tiger. They could either be independent events or programmed as part of an annual Tiger Day Celebration as discussed in recommendation 6. With only a minor financial investment HWI could serve as the sponsor of the event (providing research information, documents, consultations with contestants, referrals, and perhaps a large banner that could be displayed at each school during the competitions).

Recommendation 8: The Project should explore the feasibility of sponsoring school public speaking competitions and art contests related to the tiger. *(Time frame: 1 year to end-of-project.)*

Observation 9: Print and broadcast media can be utilized in nonformal EE more frequently than they are currently being used. When we hear or read about something a lot, a natural tendency is to think it's important. Regular newspaper articles and radio spots about the tiger represent an inexpensive way to keep the tiger in the public eye, thus increasing people's perception that tiger conservation is important. Virtually everyone I talked to told me that newspapers and radio stations *need* news and information. They simply do not have the time to do their own research, conduct interviews and then write stories about topics such as the environment. Lacking their own material and the time to obtain or prepare it, they often are eager to accept prepared material from outside sources. To a large extent, news releases for newspapers and radio stations can be prepared in advance by several different people and essentially "stockpiled." In this way, several weeks of planned exposure could be accomplished with very little time investment required of any one person. Although final updating may be required in the days just prior to submitting the releases, most of the work on the releases would already have been done. Obviously, newspaper and radio station personnel need to be consulted about format and length requirements so that readily usable releases can be prepared. Other ideas for capitalizing on print and broadcast media include arranging a weekly or monthly "tiger" column in local newspapers and offering to conduct a weekly program (either in person or by phone) with local radio stations or alternatively by pre-recording messages on a cassette tape and sending it in advance to the stations.

Recommendation 9: The Project should work closely with newspapers and radio stations to ensure that information about the tiger and conservation efforts *routinely* reach a larger audience than they currently reach. *(Time frame: 6 months to end-of-project.)*

Observation 10: Little is known about the key audiences for EE in the Russian Far East. Outside of purely anecdotal descriptions and widely varying opinions of what different target groups may or may not think, virtually no data exist to help guide decisions about the information content, creative approach or persuasive appeals that would work best in EE programs aimed at different audiences.

Recommendation 10: Before investing significant amounts of time and funds into program development, a systematic survey of audiences' perceptions and feelings toward the tiger and related issues (poaching, etc.) should be carried out. A standard survey instrument should be developed and administered to key audiences as follows:

Formal EE:	Students K-12 and Teachers K-12
Nonformal EE:	Current Hunters and Future Hunters (males in K-12 students)

As you know, a preliminary survey of this type is already underway with hunters. Ideally, data collection would be expanded to random samples of the above audiences throughout the Project region and follow-up data would be collected once differences between the audiences became apparent. *(Time frame: immediate to 1 year for initial data collection and analysis.)*

FOOD HABITS OF AMUR TIGERS IN SIKHOTE-ALIN ZAPOVEDNIK AND THE RUSSIAN FAR EAST, AND IMPLICATIONS FOR CONSERVATION

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Abstract: Diet of Amur tigers (*Panthera tigris altaica*), based on kill composition, is reported for 54 years of data in Sikhote-Alin State Zapovednik, Russia. Although relative importance changed over time, elk (*Cervus elaphus*) and wild boar (*Sus scrofa*) were consistently the two key components of the diet, together accounting for 84% of kills. Adults were predominant, but young comprised 30–36% of the kill composition. From 1992–1994 kill composition of radio-collared and non-collared tigers did not vary, but individual tigers did show variation in prey selection. Tigers killed an average 4.3 dogs and 4.2 domestic livestock per year between 1975–1994, but recent trends suggest that fewer are being killed. An inverse linear relationship exists in the percentage of the diet composed of wild boar and elk for Amur tiger, suggesting, while reduction in density of one prey species can be presumably compensated for by the other, some combination of the two at relatively high densities will provide the best chances for survival of the Amur tiger in the Russian Far East. We suggest that habitat quality is an ill-defined concept for tigers, and that there are few ecological restraints that relate to habitat quality except as they relate to habitat for key prey species. Tigers across their entire range appear to be intricately linked to ecologically similar ungulate assemblages, and therefore one of the primary goals of a tiger conservation program should be identification of and management for the key prey species.

Key words:

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INTRODUCTION

Information on food habits is of basic importance in understanding the natural history and ecology of large carnivores. Because acquisition of food is a fundamental component of every predators' daily existence, knowledge of food selection is critical to understanding life history strategies and developing sound conservation recommendations. The Amur, or Siberian tiger (*Panthera tigris altaica*) is presently threatened with extinction. With only a handful of Amur tigers lingering in Northeast China and possibly North Korea, the Russian Far East (including Primorye and Khabarovsk Krais, or Provinces) represents the last stronghold of the subspecies. In 1985 Pikunov (1993) estimated that there were 240–250 individuals remaining in the Russian Far East. Since that time, increased poaching pressures have undoubtedly reduced population size, although the exact magnitude of this impact is unknown (Miquelle et al. 1993, Mills and Jackson 1994).

Although there exists a considerable body of information on food habits of the Amur tiger, much of the literature is available only in Russian, or has not been published. Our objectives are 5-fold: first, to present an extensive body of data on tiger food habits in Sikhote-Alin State Zapovednik covering 54 years. Secondly, we compare kill composition from this extensive period with results from an intensive, radio telemetry study of tigers in the same region from 1992–1994. Thirdly, we summarize existing data on the food habits of Amur tigers in Primorye and Khabarovsk Provinces, and compare results from Sikhote-Alin Zapovednik with other regions of the Russian Far East. Fourthly, we compare food habits of the Amur tiger with that of other subspecies, and suggest that ecologically similar ungulate complexes are linked to survival of the tiger throughout its range. Finally, we suggest that habitat quality for tigers is poorly defined, and that, in consideration of the key linkage between predator and prey assemblages, conservation plans for tigers will be most effective by managing habitat for prey species, rather than by attempting to provide quality habitat for tigers per se.

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STUDY AREA AND METHODS

Study area

Sikhote-Alin State Zapovednik (SASZ), located in northeast Primorye Krai of the Russian Far East, was gazetted in 1935, and at that time encompassed 1,000,000 ha. It's size has changed several times over the past 60 years, the most dramatic event being a severe reduction to 100,000 ha in 1951. Presently, the Zapovednik is 400,000 ha. Zapovedniks in Russia are a system of highly protected reserves: access is restricted to scientists and forest guards. Therefore, human impact on both tigers and prey species in Sikhote-Alin Zapovednik is minimal.

We report information on kills of wild and domestic animals in and adjacent to SASZ, the total region encompassing approximately 500,000 ha. Although the human population is relatively sparse outside the Zapovednik, villages are located at all corners, with the bulk of human population situated along the coast of the Sea of Japan. Terney and Plastun, the 2 largest villages, have a population of approximately 4,000 each. Small scale agriculture, including rearing of domestic animals, hunting, and trapping are important components of the local economy, and lands adjacent to the Zapovednik are heavily used for both agrarian and subsistence purposes.

The central feature of the SASZ is the Sikhote-Alin Mountains, a low range (most peaks are below 1,200 m) that parallels the coast of the Sea of Japan. Coastal drainages are relatively short; on the inland side the upper reaches of larger rivers drain into the Ussuri, and, ultimately, the Amur River.

On the coastal side of the SASZ, the dominant plant communities are oak and mixed conifer-broadleaved forests. Mongolian oak (*Quercus mongolica)* is most common near the coast, where a series of fires in the last century destroyed the original forest type. More inland, and at higher elevations on the coastal side, a mixture of deciduous and conifer forests persist, characterized by Korean pine *(Pinus koraiensis*), larch (*Larix komarovii*), birches (*Betula costata*, *B. lanata*, and others), basswood (*Tilia amurensis*), and fir (*Abies nephrolepis*). On the inland side of the Sikhote-Alin crest, boreal forests are dominant, including firs, spruce (*Picea ajanensis*), and larch.

As with the plant communities, the faunal complex of Sikhote-Alin Zapovednik is represented by a mixture of Asian and boreal life forms. The ungulate complex is represented by 7 species, with Manchurian elk (*Cervus elaphus xanthopygus*) and Ussuri wild boar (*Sus scrofa ussuricus*) being the most common: both are found throughout SASZ. Manchurian moose (*Alces alces cameloides*) are near the southern limits of their distribution, and are sparsely distributed in the inland boreal forests. Sika deer (*Cervus nippon*), near their northern limits, are primarily confined to the coastal zone. Musk deer (*Mochus moschiferus*) are associated with the upper elevation conifer forests, and roe deer (*Capreolus capreolus bedfordi*) are confined to regions of limited snow depth. Ghoral (*Nemorhaedus caudatus*) are restricted to coastal cliffs.

Both brown bear (*Ursus arctos*) and Himalayan black bear (*Ursus thibetanus*) are common. Wolves are present but rare in and around SASZ, though the density has fluctuated over the period of study (Matyushkin 1992). Medium-sized mammals found in the Zapovednik include racoon dogs (*Nyctereutes procyonoides*), badgers (*Meles meles*), lynx (*Lynx lynx*), red fox (*Vulpes vulpes*) and six species of mustelids: yellow-throated marten (*Martes flavigula*), sable (*Martes zibellina*), ermine (*Mustela nivalis*), Siberian weasel (*Mustela sibirica*), mink (*M. vison*), and otter (*Lutra lutra*).

Tiger populations have fluctuated dramatically within SASZ (Smirnov and Miquelle, in press). Populations were decreasing throughout the Russian Far East, including the Zapovedniks, through the late 1930's and 1940's due to hunting, poaching, and capture of cubs (Matyushkin et al. 1980). Hunting of tigers was outlawed in 1956. Despite this prohibition, tigers were virtually absent in Sikhote-Alin Zapovednik between 1951 and 1966. Population density increased rapidly through the 1970's and 1980's, apparently reaching a peak in the early 1990's (Smirnov and Miquelle, in press) when poaching activity increased substantially (Miquelle et al. 1993).

Methods

Estimates of tiger diet composition in Sikhote-Alin Zapovednik are based on the relative abundance of kills located and reported by researchers and forest guards. Kills are located either by following tiger tracks in the snow (Kaplanov 1948, Abramov et al. 1978, Yudakov and Nikolaev 1987), by observing behavior of scavengers such as ravens and crows, or by chance encounters during routine patrol by forest guards. The same basic techniques for location of kills has been employed for 50 years.

The first work on food habits of tigers in Sikhote-Alin Zapovednik was conducted by Kaplanov (1948). This information is apparently included in the report by Shamikin (in Abramov, 1962) for the period 1933–1948. No information is available from 1949–1956, when tigers were mostly absent from the Zapovednik (Smirnov and Miquelle, in press). Occasional dispersers may have been present in the early 1960's, but recolonization of the Zapovednik apparently occurred in the mid-60's. Because of the scarcity of data, information from during the 1957–1969 period was combined. During 1964–1972, 1977, and 1984 Matyushkin conducted investigations of tigers in the Zapovednik (Matyushkin 1977, 1991, 1992; Matyushkin et al. 1981). From 1972 to the present, Smirnov (1990) coordinated data collection by forest guards and researchers. Therefore, beginning in 1970, when tigers were relatively abundant, a fairly consistent effort in data collection has been maintained (1970–1994).

Table 1. Diet composition of Amur tigers, based on 552 located kills, during 7 time periods between 1933 and 1994, in Sikhote-Alin State Zapovednik, Primorye Province, Russia. Numbers in parentheses refer to number of kills reported for each time period.

Prey species	Percent of total kills reported							
	1933–1948 (59)	1957–1969 (21)	1970–1974 (33)	1975–1979 (38)	1980–1984 (134)	1985–1989 (108)	1990–1994 (159)	TOTAL (552)
Wild ungulates								
Elk	22.0	71.5	78.7	73.7	41.8	62.0	59.7	54.3
Wild boar	35.6	19.0	15.2	21.1	43.3	22.2	27.0	29.5
Roe deer	3.4	0.0	6.1	0.0	9.0	4.6	8.9	6.3
Musk deer	13.6	0.0	0.0	0.0	3.0	0.9	0.6	2.5
Moose	10.2	9.5	0.0	2.6	0.0	0.0	0.6	1.8
Ghoral	0.0	0.0	0.0	0.0	0.7	2.8	0.6	0.9
Sika deer	0.0	0.0	0.0	0.0	0.7	0.0	1.3	0.5
Other								
Tiger	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.2
Bear	8.5	0.0	0.0	2.6	0.7	3.7	0.6	2.2
Wolf	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.2
Lynx	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Badger	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2
Raccoon dog	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.2
Mink	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.2
Grouse	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Subtotal ungulates	84.8	100.0	100.0	97.4	98.5	92.6	98.7	96.0
Subtotal other	15.2	0.0	0.0	2.6	1.5	7.4	1.3	4.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

From 1992–1994, eleven tigers were captured and outfitted with radio-collars. During this period, in addition to locating kills by the traditional methods, kills were located based on movement patterns of radio-collared tigers. Monitored animals that remained in one area for more than 1 day were suspected of having made a kill, and the area was investigated after tigers left the site. Data reported for radio-collared tigers covers the period from January 1992 through November 1994.

Information on radio-collared animals may be a less biased indication of food habits because collection of kills was not dependent on travel routes of researchers or forest guards (e.g., easy travel routes along river bottoms may favor discovery of kills representing prey species which select such habitats) or may have different biases. Therefore, we compare species and age composition of kills by radio-collared and non-collared tigers during the period 1992–1994 to assess potential differences in the two methods.

The 25-year period with consistent effort at data collection, 1970–1994, was divided into 5-year blocks. In combination with the two earlier periods (1933–1948 and 1957–1969), we assessed variation in food habits of tigers over all 7 time periods using a chi-square analysis. We examined cell chi-square values to assess the importance of specific periods on the total chi-square value and then tested the importance of specific periods by hypothesizing a non-significant total chi-square when key time periods were deleted (Zar 1984).

The sex and age composition of prey killed by tigers for the period 1992–1994 was analyzed and compared to fragmentary information from earlier periods. Where information was available, we classified all kills as adult, yearlings, and young of the year, based on tooth eruption patterns (Bubenik 1982, Bromley 1964). Seasonal variation in composition of prey was also analyzed.

Because kill composition may be a poor indicator of relative importance of prey species (Karanth and Sunquist 1995), we estimated percentage biomass contribution of each prey species to the diet of tigers by multiplying number of kills by weight, specific for species, sex, and age. Weights of animals were based on data provided by Bromley and Kucherenko (1983),

Table 2. Sex and age composition of Manchurian elk and Ussuri wild boar kills made by Amur tigers in Sikhote-Alin State Zapovednik, 1992–1994. Kills were separated into three age classes: adults (>2 years), yearlings (between 12 and 24 months), and young (<12 months). For each species the percentage of kills in each age class, and sex ratio (males:females) is presented.

Age	Manchurian elk				Ussuri wild boar			
	% of total		Sex ratio		% of total		Sex ratio	
	n	%	n	M:F	n	%	n	M:F
Adults	33	51.6	29	1:2.2	18	60	18	1:1
Yearlings	8	12.5	7	1:0.8	3	10	1	
Young	23	35.9	11	1:1.7	9	30	5	1:4
TOTAL	64	100.0	47	1:1.8	30	100.0	24	1:1.2

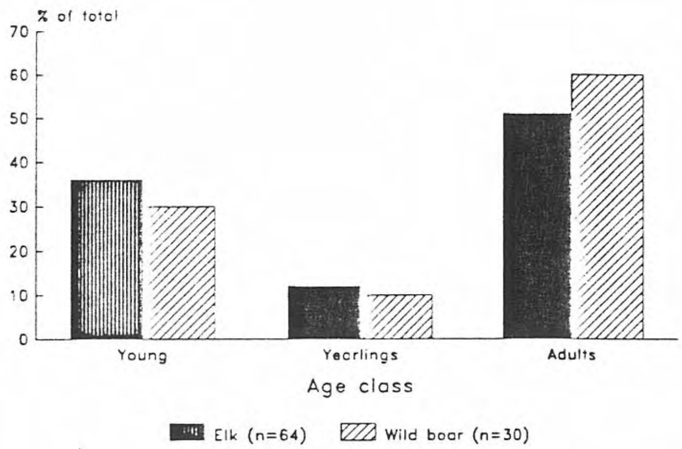

Fig. 1. Age composition of Manchurian elk and Ussuri wild boar kills made by Amur tigers in Sikhote-Alin State Zapovednik, Primorye, Russia between 1992–1994.

Fig. 2. Comparison of relative importance of prey species, based on numbers killed and biomass contributed to the diet, for Amur tigers in Sikhote-Alin State Zapovednik, Primorye, Russia, 1992–1994.

Bromley (1964), and Krevosheyev (1984). We assumed that the same percentage of each kill was consumed from all species and sex-age classes (Hornocker 1970, Ackerman et al. 1986), and therefore simply used total weight of animals as a relative comparison.

We compared the information in Sikhote-Alin to 5 other food habit studies of Amur tigers where at least 50 kills were reported. The relationship between relative abundance of wild boar and elk in the diet was assessed with a regression analysis.

Information on kills of domestic animals comes from 2 sources. Official reports are made to the regional government by people seeking compensation for livestock killed by tigers. Because not all people file claims, additional information came through discussions with local farmers and livestock owners. Information on predation on dogs is mostly derived from anecdotal reports of hunters who lost dogs while in the forest. We included only those reports where kills were made within 30 km of Zapovednik boundaries. The source of information and the types of biases associated with collection of domestic and wild kills makes the data incomparable, so the data sets are presented separately.

Chi-square tests are used to assess variations in kill composition. Where biases could occur due to small expected frequencies, log-likelihood ratios are used. All means are reported with ±95% confidence intervals.

RESULTS

Information on food habits of tigers in Sikhote-Alin Zapovednik is based on reports of 552 kills of wild and 197 domestic animals over 54 years (Tables 1, 5). With the exception of years 1949–1956, a continuous record of kills observed by forest guards and biologists has been maintained. During the mid-sixties (1964–1966), when there were no resident tigers in the Zapovednik (Smirnov 1986), no kills were found. For the 25-year period beginning in 1970, an average 18.40±6.92 kills (non-domestic) were found each year, but yearly records vary dramatically from 3 (1971 and 1973) to 76 (1984). Using the yearly average estimate of tigers in the Zapovednik for 1966–1991 (Smirnov and Miquelle, in press), there is a significant but poor relationship between number of tigers and number of kills reported each year (r^2=0.34, F=12.7, p=0.001).

We looked for biases in the data collection method in two ways. First, we compared species composition of kills made by radio-collared and non-collared tigers between 1992–1994 to assess differences dependent on the method of finding kills. We found no significant differences in species composition of the kills of non-collared and collared tigers (χ^2=2.34, p>0.05). Therefore, this information is combined for the 5-year period 1990–1994.

Secondly, we compared age distribution of elk and wild boar kills for the periods 1970–1990 and 1992–1994. The age composition of elk killed between 1992–1994 was not significantly different than that of earlier periods (χ^2=8.0, p> 0.05), although young were more poorly represented in the earlier period. In contrast, there was a significant difference in age composition of wild boar between earlier periods and 1992–1994 (χ^2=14.7, p<0.05). This difference is largely due to the very large number of yearlings reported killed in earlier periods. Although we cannot assess if the difference is due to changes in the age composition of the boar population, we believe that forest guards may have mistakenly identified adult female wild boar as young males (the canine, or tusk, is similar in size, and is often used as a diagnostic trait). To avoid this potential bias in sex and age distribution, we report only for the years 1992–1994.

Large ungulates are the primary component of the diet of tigers in SASZ (Table 1). Ungulates comprised over 96% of the total number of kills, and of that, 84% was wild boar and elk. Roe deer were third in importance, but contributed only 6.1% of the total kill composition. Except for the earlier periods of study (1933–1948 and 1957–1969), musk deer and moose were minor components of the diet. Ghoral and sika deer, both rare in the Zapovednik, were minor items in the kill composition.

Of the non-ungulate species, only bear kills were consistently found throughout the study period, although the frequency was low. In all cases, tigers appeared to have eaten the bear carcasses. Reports of predation on other predators was rare. Only one instance of tiger predation on wolves was reported. Kills of smaller animals were rarely found.

Because elk and wild boar were the only consistently important components of the diet, we combined all other species and used 3 food categories to assess variation in kill composition over 7 time periods. Significant differences were found when all 7 periods were included in a 3×7 contingency table (χ^2=71.8, *df*=12, $p<$ 0.001). Period 1 (1933–1948) and Period 5 (1980–1984) contributed disproportionately large percentages to the total chi-square value. For further testing, the period 1957–1969 was deleted because small expected frequencies would create biases in the analysis. The null hypothesis that 2 periods (1933–1948 and 1980–1984) were significantly different from the other 4 is supported by the fact that the chi-square value with these 2 periods deleted is insignificant (χ^2=7.8, *df*=6, *p*=0.25), while, when only one or the other of these 2 periods is deleted, significant chi-square values remain (for 5 periods 1970–1994, χ^2=28.7, *df*=8, $p<$0.001, and for 5 periods including 1933–1948 and deleting 1980–1984, (χ^2=51.7, *df*=8, $p<$0.001).

The outstanding difference between 1933–1948, 1980–1984, and the other 5 periods is the high percentage of wild boar in the diet (greater than 35%) and the small percentage of elk (less than 45%) (Table 1). In all other periods, elk kills contributed over 60% to total kill count. Age composition of elk and boar kills was similar: adults made up the majority of kills (52–60%), yearlings were relatively rare (10–12%), and young of the year represented 30–36% (Table 2, Fig. 1). Adult cow elk were 2.2 times more commonly killed than bulls, while male and female wild boar were equally represented in the kill composition (Table 2). Age distribution of elk and wild boar kills were similar (Fig. 1).

Diet composition varied very little whether estimates are based on body weight or number of kills for the period 1992–1994 (Fig. 2). Because weights of boar and elk are roughly similar, and age distribution of kills was similar, estimates of biomass contribution to the diet vary little from estimates based strictly on numbers of individuals.

Information from 5 radio-collared tigers was sufficient to assess individual variation in kill composition. Individual tigers showed noticeable variations in kill composition (Fig. 3). Elk were the most important component of the diet of all 4 tigresses, but for the young adult male, more wild boar kills were reported than elk kills. Differences were not only due to differences in relative abundance of prey species: female F8 and male M2 maintained virtually identical home ranges, but selected prey differentially. Differences in prey selection may reflect age and hunting ability of tigers. While sample sizes are too small to permit statistical comparisons, 2 of 3 young tigresses (F1 and F8) appeared to rely more on species other than elk and wild boar, primarily roe and sika deer, which are smaller and perhaps easier to handle for relatively young and inexperienced tigers. Such an interpretation is only weakly supported by estimates of average weight of kills (Table 3). Average kill weight of young females F1 and F8 were lightest, but variation was great, and there were no significant differences among any of the 5 tigers analyzed (Table 3).

There was significant seasonal variation in kill composition for the period 1992–1994 (G=17.9, $p<$0.05) (Table 4). Elk were the most common component of the kill composition in all seasons, but in summer, a greater variety of species were taken: 35% of all kills were other than elk and boar. In winter, boar were more heavily preyed upon than in other seasons.

Dogs were the most commonly reported domestic animal killed by tigers in and adjacent to SASZ between 1957 and 1994 (Table 5). Except for two time periods, dogs comprised 50% or more of the domestic kills. Killing of domestic livestock, primarily cows and horses, make up nearly all the remainder of domestic animals reported killed by tigers (Table 5). Since 1975, when the tiger population had recovered substantially, an annual average of 4.35±2.1 dogs and 4.25±1.68 livestock were reported killed by tigers in the vicinity of SASZ. There have been dramatic changes in the number of livestock depredations reported over time (Fig. 4). Kills of livestock and all domestic animals peaked between 1980 and 1984, and remained at relatively high levels until 1989. The number of kills has dropped since 1990. Of the 73 located kills made by radio-collared tigers between 1992–1994, 5 (6.8%) were domestic animals.

Results of kill composition data collected in Sikhote-Alin

Table 3. Weights of kills made by radio-collared Amur tigers in Sikhote-Alin State Zapovednik, 1992–1994.

Tiger			Weight of kills		
Name	Age (years)	Sex	n	$\bar{x}$	95% CI
F8	2–4	female	17	77.5	26.1
F1	1.5–4	female	10	84.1	47.8
F6	>5	female	14	89.5	29.9
F3	2–4	female	8	151.7	38.9
M2	2–4	mele	14	92.3	33.2

Table 4. Seasonal distribution of kills made by tigers in Sikhote-Alin State Zapovednik, 1992–1994.

Season	n	Percentage of total kills found			
		Manchurian elk	Wild boar	Other	Total
Winter	53	47.2	41.5	11.3	100
Spring	25	72.0	16.0	12.0	100
Summer	20	60.0	5.0	35.0	100
Fall	16	62.5	31.2	6.2	100
TOTAL	114	57.0	28.1	14.9	100

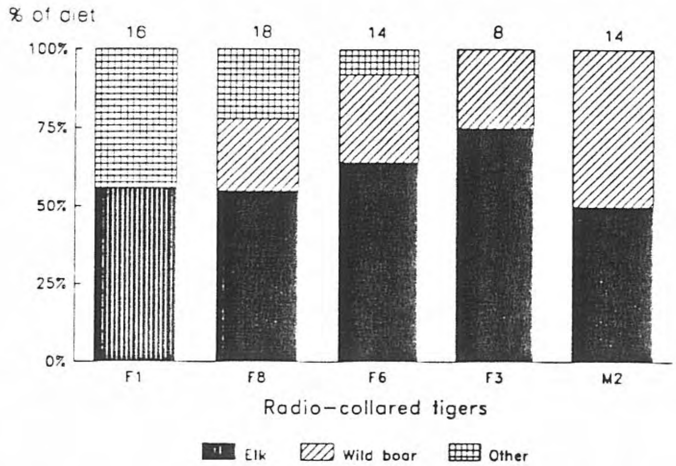

Fig. 3. Comparison of kill composition for 5 radio-collared Amur tigers (4 females and 1 male) in Sikhote-Alin State Zapovednik, Primorye, Russia, 1992–1994. Numbers above figure represent sample sizes for each tiger.

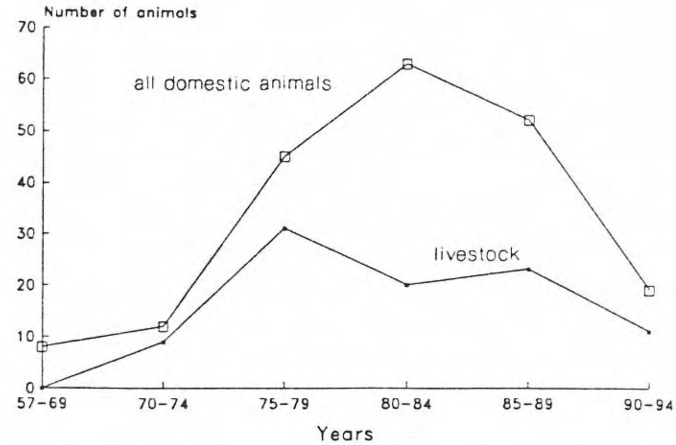

Fig. 4. Number of domestic animals killed by Amur tigers in and around Sikhote-Alin State Zapovednik, Primorye, Russia, for 6 time periods between 1957 and 1994. Differences between "livestock" and "all domestic animals" largely reflect the number of dogs being killed by tigers.

show a similar pattern to information collected in other parts of the Amur tiger's range in Russian Far East (Table 6). Ungulates make up 85% or more of the kills found. Elk and wild boar are the two dominant ungulates in the diet in every study, together contributing 57–85% of the kill composition. Using the data from 7 time periods in Sikhote-Alin, and the other 5 sources in Table 7, a clear inverse linear relationship exists between percentage of elk and boar in the diet of Amur tigers (Fig. 5).

DISCUSSION

The quantity of reported kills varied considerably among years, and although there was a significant relationship between tiger numbers and number of kills found, the relationship was weak. Other factors likely also had an impact on number of kills reported, including incentive of forest guards, and distribution of kills. For instance, in the heavy snow winters of 76–77 and 83–84, ungulates concentrated in valleys and many kills were located along trails routed along river bottoms (Matyushkin 1992). Despite these sources of variation, methods of locating and reporting kills have been consistent, so that most biases have remained constant. Therefore, although numbers of kills found has varied, differences over time in composition of kill data likely reflect real changes in prey composition of the tiger diet within SASZ.

The one exception to constancy in methodology is the results of the earliest period (1933–1948). Apparently, these results reflect samples from both kills and excrement (Matyushkin 1992) confounding meaningful comparisons since variation in methodology may explain observed variation in diet composition.

Manchurian elk and Ussuri wild boar made up the majority of the diet of tigers in Sikhote-Alin Zapovednik over the entire 54 years of study. However, their relative importance varied over time, apparently in relationship to changes in density (Matyushkin 1992). This relationship will be investigated in future studies.

Significant differences existed in age composition of kills between the older data set (1970–1990) and recent information (1992–1994) for wild boar and a trend in that direction for elk. In fact, as with many studies of large carnivores based on kill composition, predation on young animals and smaller species is probably underrepresented in both periods. Age composition is probably most skewed in summer when tigers spend relatively little time at kill sites of neonates, and it was more difficult to locate kill sites even if a kill was suspected. With large ungulates, tigers typically spent 2–4 days at a kill site (Yudadov and Nikolaev 1987, Miquelle et al., unpubl.), increasing the probability of detecting a kill using radiotelemetry locations. However, in summer tigers spent little time at kill sites of young — occasionally only a few hours; such locations are difficult to differentiate from resting sites. In winter, tracks in snow and ravens provided ready clues to the location of kills, while in summer ravens appeared less adept at locating kills, and tracks were scarce.

For the same study area for the period 1964–1984 (data collected during 7 winters) Matyushkin (1992) reported a ratio in kill composition of elk males:females + young as 1:1.75. For 1992–1994, that ratio is 1:2.6, suggesting a higher use of bulls in the earlier period. However, Matyushkin (1992) emphasized that young were taken in greater percentage than they occurred in the population. Sex and age composition of elk kills in Lazovsky Zapovednik (in southern Primorye Krai), are similar to the present study: 50% of kills were adults (51.6% in SASZ) with an adult male:female sex ratio of 1:2.75 (compared to 1:2.2 in SASZ) (Zhivotchenko 1981). In Lazo 50% of elk kills were calves, compared to 36% in Sikhote-Alin. Zhivotchenko (1981) did not report yearlings separately, and they were apparently included as adults. Sex and age composition of wild boar kills in Lazovsky differs from this study: in SASZ the sex ratio of adult wild boar was equal, in Lazo it was 1:4, favoring females, a value that more likely reflects the ratio in the population. Young boar comprised 82% of the boars killed in Lazovsky: in Sikhote-Alin only 30% of the boar killed were young. Both samples were relatively small (n=30 and 27) and differences may only reflect sampling variation.

Seasonal variation in prey selection of tigers in Lazo was also similar to Sikhote-Alin. Although sample sizes are small for each study, both demonstrated that wild boar were more commonly taken in fall and winter than spring and summer, and elk were more important in spring and summer. In Lazo, however, tigers also depend heavily on sika deer, which are much more common. Since Sikhote-Alin Zapovednik lies near the northern limit of sika deer range, they are sparsely distributed, and represent a small percentage of available prey to tigers.

Tigers will kill other carnivores, but it is not clear if competition is a driving factor. Schaller (1967) noted that tigers will kill sloth bears (*Melursus ursinus*), and McDougal (1988) reported 5 leopards were found killed by tigers within 21 months of each other in Nepal. All food habit studies of Amur tigers report bears as a component of the diet (Table 6): tigers in Sikhote-Alin killed both brown and Himalayan black bears. Of 6 cases reported in Sikhote-Alin Zapovednik, 3 were Himalayan and 3 were brown bears. Adult brown bears in this region can weigh over 300 kg (unpubl. data), will often appropriate kills from tigers, and have been reported to kill young tigers (Hepter and Sudski 1972, Kucherenko 1985). Such animals are immune from attack by tigers in summer, but tigers will kill brown bears in their dens in winter (Bromley 1965, Kaplanov 1948).

There is circumstantial evidence that tigers will eliminate wolves from regions through direct competition. Observations of tigers killing wolves are rare: only one record exists for Sikhote-Alin (Table 1), and one for Lazovsky Zapovednik (Matyushkin et al. 1980). Nonetheless, the fact that tigers frequently kill dogs suggests that they may also readily kill wolves. Matyushkin et al. (1980) reported that wolf distribution shifted after 1966 when tigers recolonized Sikhote-Alin Zapovednik, and around Lazo, wolves became common around 1926 when tigers were practically eliminated (Zhivotchenko 1977). When the tiger population rebounded, the wolf population again decreased.

Reports of livestock depredation, and killings of dogs, have to a large extent reflected the density of tigers in the Zapovednik and surrounding areas. Because of biases in the data, no attempt has been made to numerically calculate contribution of domestic animals to the diet of tigers in SASZ, but it is clear that livestock predation is relatively rare, and that domestic animals make up only a minor portion of the diet of tigers in this region. Nearly 7% of kills made by radio-collared animals were domestic animals, but our record of domestic animal kills probably represent nearly 100% of actual occurrences, while our record of wild animal kills is only a small percentage. Because of the small human population surrounding the SASZ, most of the incidences of tiger predation on domestic livestock are probably recorded. Rates of predation are low largely because of the relatively few numbers of livestock, and the grazing system employed. Many villagers own one or a few milk cows, and these animals return to their barn every evening, reducing the chances of predation by tiger. Even in more remote, larger farms, in many cases animals are put in barns nightly, and people are assigned to watch herds during the day.

Throughout Primorye Province the situation is more severe (Matyushkin et al. 1980). The increase of the tiger population through the 1960's and 70's was concurrent with a decrease in ungulate populations due to overhunting, with the result that predation on domestic animals increased substantially. From 1920–1960 only 162 reports of tiger predation on domestic animals occurred province-wide; from 1961–1965 100 attacks were reported; and from 1966–1970 386 attacks were reported. Predation is apparently more common to the south, where economic development is more intensive, and human and domestic animals densities are higher.

It is not entirely clear why predation on domestic animals near the SASZ has decreased in the recent past. This may partly reflect less interest in stock raising, but predation on dogs also appears to have decreased. The drop may reflect that shooting of depredating tigers has become more common, eliminating the individuals who habitually kill livestock or reside near

Table 5. Tiger depredation on domestic animals in vicinity of Sikhote-Alin Zapovednik, Primorye Krai, Russia, during 7 time periods between 1933 and 1994. Sample sizes for each period in parentheses.

Species	Percent of total kills reported							
	1933–1948 (0)	1957–1969 (8)	1970–1974 (12)	1975–1979 (45)	1980–1984 (63)	1985–1989 (52)	1990–1994 (17)	TOTAL
Dog	0.0	100.0	25.0	31.1	57.1	55.8	41.0	49.2
Cow	0.0	0.0	66.7	44.4	14.3	17.3	24.0	25.4
Horse	0.0	0.0	8.3	22.2	15.9	19.2	35.0	18.8
Pig	0.0	0.0	0.0	2.2	1.6	5.8	0.0	2.5
Sheep	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.5
Chicken	0.0	0.0	0.0	0.0	11.1	0.0	0.0	3.5
TOTAL	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

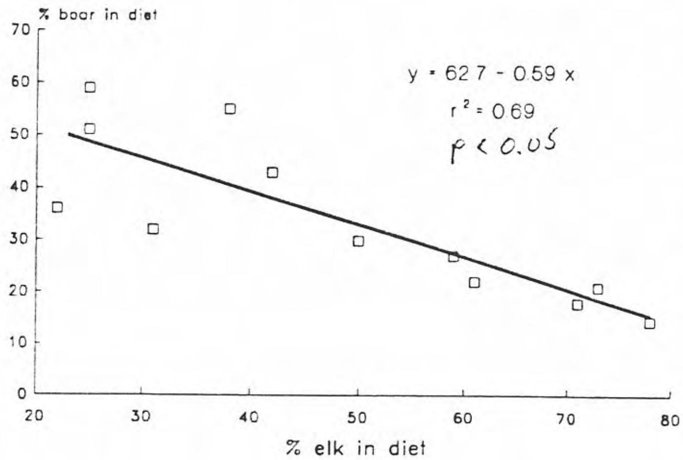

Fig. 5. The relationship between number of Ussuri wild boar and Manchurian elk in kill composition of Amur tigers in Russian Far East, based on 7 time periods of study in Sikhote-Alin State Zapovednik, and 5 other studies in Primorye and Khabarovsk Krais (see Table 6).

settlements. Farmers who suffer repeated loses to predation have probably always killed tigers. However, with recent privatization of farms, individual farmers carry the burden of depredation directly. We suspect that killing of depredating tigers has increased. One radio-collared tiger is responsible for the death of at least 2 calves and one colt, and her life has been threatened by more than one farmer. Compensation only partly alleviates the loss, and state-determined rates for compensation have left farmers dissatisfied.

MANAGEMENT IMPLICATIONS

As noted by Matyushkin et al. (1980) and Matyushkin (1992), it is widely believed that welfare of the Amur tiger population is dependent on wild boar. Because boar overwinter survival is closely linked to mast crops, and because the primary mast-producing tree is the Korean pine, large-scale harvesting of this commercially valuable tree could be a potential threat to tiger survival. Matyushkin (1992) and the data presented here indicate that the importance of wild boar has likely been exaggerated. Figure 5 demonstrates that tigers can, and usually do, rely on elk more than on boar, and that either can provide the bulk of the diet. Forestry management practices could favor one prey over the other, potentially without any serious detriment. Nonetheless, these two prey species should be maintained in any forest complex that is being managed for Amur tigers. Each prey species responds to environmental changes differently, and the impact of fluctuations in either prey species can be dampened if the other prey also exists in sufficient abundance. In this scenario, the large-scale selective harvesting of pine is still seen to be a threat to tiger survival.

In concurrence with studies on other tiger subspecies (Schaller 1967, Kruuk 1986, Sunquist and Sunquist 1989, Seidensticker and McDougal 1993, Karanth and Sunquist 1995), our data suggest that Amur tigers specialize on medium to large-sized ungulates. Despite the large geographic range of subspecies, tigers appear to be associated with very similar sets of ungulates across their entire range. (Table 7): 3 size classes of cervids (except medium-size deer missing from Java and Sumatra) and wild pigs are present throughout tiger range. In all places except Russia, a large bovid is or was present. What is of interest here is not the percentages that each species contributes to the diet of tigers, which varies from site to site based on availability and relative density, but that the complex of species is relatively similar among all sites. Seidensticker (1986) has suggested that tiger distribution in South Asia is linked to an ungulate assemblage whose essential component is large cervids. We suggest that this relationship extends into the Russian Far East, and that in some regions suids may be a more important component than

Table 6. Summary of kill composition data for Amur tiger in the Russian Far East, 1933–1994. Domestic animals except dogs are excluded. Data presented by area, with years of study. Sample sizes are in parentheses.

Species	Primorye[a] 1957–1959 (40)	Primorye[b] 1958–1987 (690)	Lazovksy Zapovednik[c] 1973–1979 (336)	Central Sikhote Alin[d] 1970–1973 (64)	Khabarovsk northern Primorye[e] no data (131)	Sikhote Alin Zapovednik[f] 1933–1994 (552)
Elk	50.0	37.1	31.0	25.0	25.0	54.3
Wild boar	30.0	54.8	31.8	59.4	51.0	29.5
Roe deer	2.5	2.0	5.3	6.3	5.0	6.3
Sika deer	5.0	0.1	18.2	0.0	0.0	0.5
Musk deer	2.5	2.0	0.0	3.1	4.0	2.5
Moose	2.5	0.1	0.0	0.0	3.0	1.8
Ghoral	0.0	0.0	2.9	0.0	0.0	0.9
Bear	5.0	7.3	1.5	3.1	6.0	2.2
Other	2.5	0.3	9.0	3.1	6.0	1.8
TOTAL	100.0	103.7[g]	100.0	100.0	100.0	100.0

[a] Abramov 1962; [b] Abramov et al. 1978; [c] Zhivotenko 1981; [d] Yudakov and Nikolaev 1987; [e] Kucherenko 1985; [f] this study, [g] as reported in article.

Table 7. Summary of ungulate assemblages in tiger range (after Seidensticker 1986).

Type	Chitwan Nepal[a]	Khana India[b]	Nagarahole India[c]	Sunderbans Bangladesh[d]	Huai Kha Khaeng Thailand[e]	Java[f]	Sumatra[g]	Sikhote-Alin Russia[h]	Lazovsky Russia
Large deer									
Alces alces								present	
Cervus elaphus								present	present
C. unicolor	present	present	present		present		present		
C. duvauceli		present		formerly					
C. schomburghi					formerly				
C. timorensis						present			
Medium sized deer									
C. nippon								present	present
Capreolus capreolus								present	present
Axis axis	present	present	present	present	rare				
A. porcinus	present			formerly					
C. eldi					formerly				
Small deer									
Muntiacus spp.	present	present	present	present	present	present	present		
Moschus moschiferus								present	present
Wild pigs									
Sus scrofa	present	present	present	present	present	present	present	present	present
S. verracosus						present			
S. Barbatus							present		
Large Bovids									
Bos gaurus	present	present	present		present	present			
Bos javanicus					present		present		
Babulus babulis				formerly	present				

[a] Sunquist 1981; [b] Schaller 1967; [c] Karanth 1993; [d] Heindrichs 1975; [e] Saidensticker 1986; [f] Rabinowitz 1989; [g] present study; [h] Zhivotchenko 1981.

has been acknowledged to date.

Despite major differences in habitat structure and composition, tigers thrive in areas where this full complex of cervids and suids is preserved. The management implications of this comparison are clear: conservation of tigers is linked to an ungulate assemblage that may vary in species composition but is comprised of species which are ecologically similar. Although tigers exist in some regions where such a complex presently does not exist (Rabinowitz 1989), the original ecosystem included such a complex, and survival of the tiger without it's primary food base is in question. In Java, Seidensticker and Suyono (1976) correlated the demise of the tiger population with the loss of the ungulate complex. In Russia, the northern limits of tiger distribution are closely linked to the northern limit of elk and wild boar (Kucherenko 1985).

Given that tigers are capable of thriving in the temperate forests of the Russian Far East as well as the jungles of Sumatra, efforts to conserve this species need not focus on habitat analyses except as they relate directly to prey species. Although there has been considerable discussion about habitat quality and critical components of habitats for tigers (Schaller 1967, Sunquist 1981, Sunquist and Sunquist 1989, Rabinowitz 1993), we argue that tigers have few ecologically constraints that relate to specific habitat requirements. For instance, it has been suggested that hunting cover is an important component of tiger habitat (Sunquist and Sunquist 1989). However, tigers successfully hunt elk and boar in the coastal forests of Sikhote-Alin Zapovednik where the only stalking cover in winter is the widely spaced trunks of oak trees. We suggest that efforts should be focused on protecting large units of forested land where management of ungulates is considered a priority, and where human-induced mortality of the tiger population can be controlled. In many areas, management for ungulates can be compatible with other human uses, and thus, tiger conservation need not directly conflict with economic realities. However, it is critical that on lands managed for multiple uses, strict control be maintained on hunting and hunters to retain high densities of critical prey species and to reduce poaching of tigers.

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