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A habitat protection plan for the Amur tiger: developing political and ecological criteria for a viable land-use plan

Dale G. Miquelle, Troy W. Merrill, Yuri M. Dunishenko, Evgeny N. Smirnov, Howard B. Quigley, Dimitriy G. Pikunov and Maurice G. Hornocker

Introduction

As the twentieth century comes to a close, conservation of the remaining five subspecies of tigers is one of the greatest challenges facing range countries and the world conservation community. Tigers have an inherent charisma and value to human societies (P. Jackson this volume), and because, like other large carnivores, viable populations of tigers require large tracts of land, conservation of tigers can provide a means for conserving native biodiversity in many range states (Noss *et al.* 1996). However, numerous challenges to the survival of tigers exist in the face of ever greater pressures from an increasing human population for decreasing land resources. Anti-poaching programmes and management of the prey base will be critical short-term conservation strategies (S. R. Galster & K. V. Eliot this volume; K. U. Karanth & B. M. Stith this volume; D. G. Miquelle *et al.* this volume chapter 6; M. Sunquist *et al.* this volume); but, long-term, the ultimate threat is loss of the large, intact natural ecosystems upon which tigers depend for survival. Tigers can co-exist with people and have for a long time survived in proximity to Man, but co-existence usually occurs along boundary zones between areas of low human disturbance (i.e. tiger habitat) and landscapes severely impacted by Man. For the tiger to survive, dramatic steps must be taken to secure large blocks of land where tigers can live in natural conditions, minimising the environmental and genetic challenges generally faced by small populations, and, as much as possible, retaining the evolutionary forces that have shaped each of the subspecies.

The Amur tiger is presently threatened with extinction in the wild. Formerly found throughout the southern Russian Far East (primarily within the Amur River Basin) to the Sea of Japan, northeast China and the Korean Peninsula, its range has collapsed to its eastern perimeter, with the only remaining viable population now occurring in Primorski and southern Khabarovski Krais (Provinces) in the Russian Far East. The last census of tigers in this region, carried out in 1996, estimated that 330–371 adult animals range between the two Krais, and may have some contact with a remnant population in Heilongjiang and Jilin Provinces in northeast China (Matyushkin *et al.* 1996). Dramatic increases in poaching activity have had significant impacts on this population (Galster *et al.* 1996). Therefore, immediate actions must be taken to ensure that this subspecies is not lost from the wild.

On the 7th of August 1995, Prime Minister Chernomyrdin signed decree no. 795 of the Government of the Russian Federation 'for conservation of the Amur tiger and other rare and endangered species of wild fauna and flora in the territories of Primorski and Khabarovski Krais'. This decree called for, among other things, the development of a national strategy for tiger conservation in the Russian Federation. This recently completed strategy identifies many management needs, including anti-poaching, environmental education, policy decisions, management of prey base,

minimisation of conflicts between people and tigers, and development of a habitat protection plan (State Committee of the Russian Federation for the Protection of the Environment 1996).

We focus on this last component: development of a habitat protection plan for the Amur tiger in the Russian Far East. Our efforts are based on a long-term, intensive research project studying the ecology of the Amur tiger (Miquelle *et al.* 1993, 1995, 1996b; E. N. Smirnov & D. G. Miquelle this volume) and our understanding of the present political situation surrounding environmental protection and tiger conservation in the Russian Far East (e.g. Yelyakov *et al.* 1993; Newell & Wilson 1996). We develop a set of goals and key components for population and habitat protection, establish both political and biological criteria to guide development of the plan, and then present a stepwise, incremental process to reach pre-established goals. We primarily focus on presentation of a core network of protected areas, but emphasise that management of non-protected lands will be just as essential to survival of the Amur tiger. We do not present this process as a blueprint for all tiger range countries, but there may be components applicable to other areas.

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Study area

Our 266 349 km² planning region included all of Primorski Krai (165 900 km²) and the southern seven Raions (Districts) of Khabarovski Krai (Bikinski, Vyazemski, Lazo, Khabarovski, Sovganski, Nanaiski and Komsomolski Raions). This region, situated between 42° and 50° 5' latitude in the southeastern corner of the Russian Far East, includes all administrative units of Russia that have a resident population of tigers (Matyushkin *et al.* 1996) (Fig. 19.1). The area can be divided into four major ecoregions, the first of which is the Sikhote-Alin Mountains, a coastal range that parallels the coast of the Sea of Japan from Vladivostok 1000 km north into Khabarovski Krai and comprises the majority of our planning region. The second ecoregion, the Amur River Basin and its tributary, the Ussuri River Basin, drains the Sikhote-Alin Mountains on the inland side, forms the border with China, and is a lowland area that has been subjected to the most intensive human development in the region. Lake Khanka, the third ecoregion, includes a massive shallow lake, but most of the surrounding steppe lands have been converted to agricultural fields. The fourth ecoregion, southwest Primorski Krai, is a narrow strip of land that borders China to the west and North Korea to the south and represents the eastern edge of the East Manchurian mountain system.

All these regions were formerly inhabited by tigers, but the highest densities probably occurred in regions now most severely impacted by Man (Baikov 1925; Kucherenko 1985). Today, due to human disturbance in the Amur Basin and Khanka regions, approximately 95% of the Amur tigers in Russia occur in the Sikhote-Alin ecosystem, and the remaining 5% in the East Manchurian Mountains in southwest Primorski Krai (Matyushkin *et al.* 1996). These two regions, formerly connected, have become separated due to a corridor of human development from Vladivostok to the city of Ussuriysk. The southwest population has become further fragmented into two components (Matyushkin *et al.* 1996).

Tiger habitat in Sikhote-Alin and the East

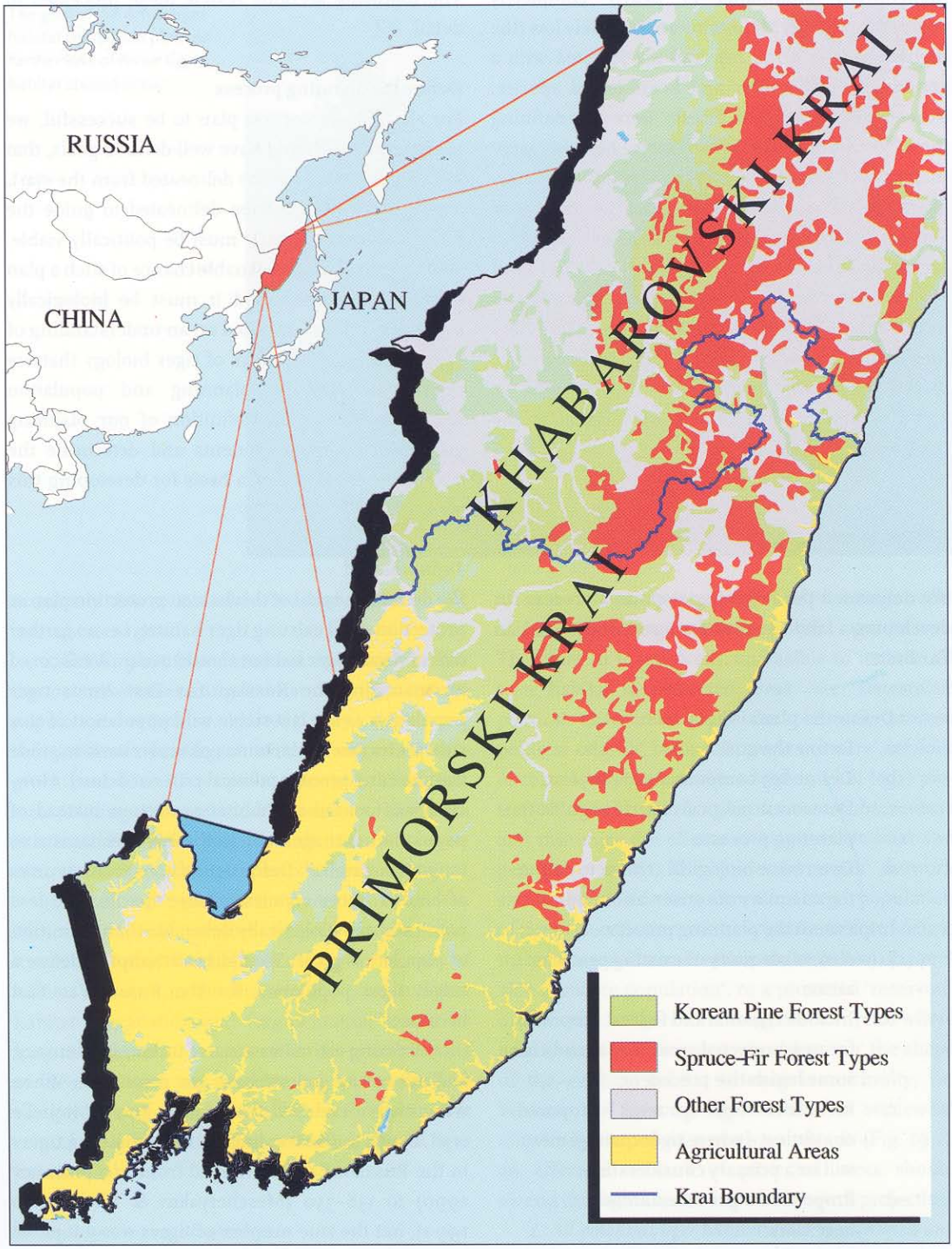


FIGURE 19.1
Study area, showing administrative boundaries of southern Khabarovski and Primorski Krais, Russian Far East, and dominant vegetative cover of the region (from Grebovoy *et al.* 1968). Potential tiger habitat is identified by suitable vegetative covers (see text) on Forest Service lands and zapovedniks.

Manchurian Mountains is nearly completely covered by forests. Mountains are relatively low (the highest peak is 2004 m), and are forested with a combination of conifer and broad-leafed species. Korean pine/broad-leaf forests were the defining forest community of this region, but the large majority of these forests have been selectively logged at various times in the past. A history of logging and fire has converted much of the region to secondary broad-leaf forests, especially oak and birch. Above 700–800 m, spruce-fir forests prevail in central Sikhote-Alin. This elevational boundary for a predominantly coniferous forest type increases to the south, and decreases northward until, at 47°20' latitude, coniferous forests occur at sea level.

Methods and results

We delineated the following steps as a process for developing a land-use plan for tigers in the Russian Far East:

1 Define the planning process:
   a. Define the goal;
   b. Define key components of the plan;
   c. Determine political criteria to guide the planning process;
   d. Determine biological criteria to define the adequacy of conservation units.
2 Implement the planning process:
   a. Assess adequacy of existing protected areas;
   b. Include regional and federal proposals for new protected areas that already have some legislative precedent;
   c. Include multiple-use areas – proposed or existing – where tiger management will be a primary consideration;
   d. Propose new protected areas if necessary;
   e. Ensure connectivity;
   f. Identify unprotected areas for inclusive tiger management plan.
3 Assess the potential effectiveness of the plan:

The following sections review these processes in detail.

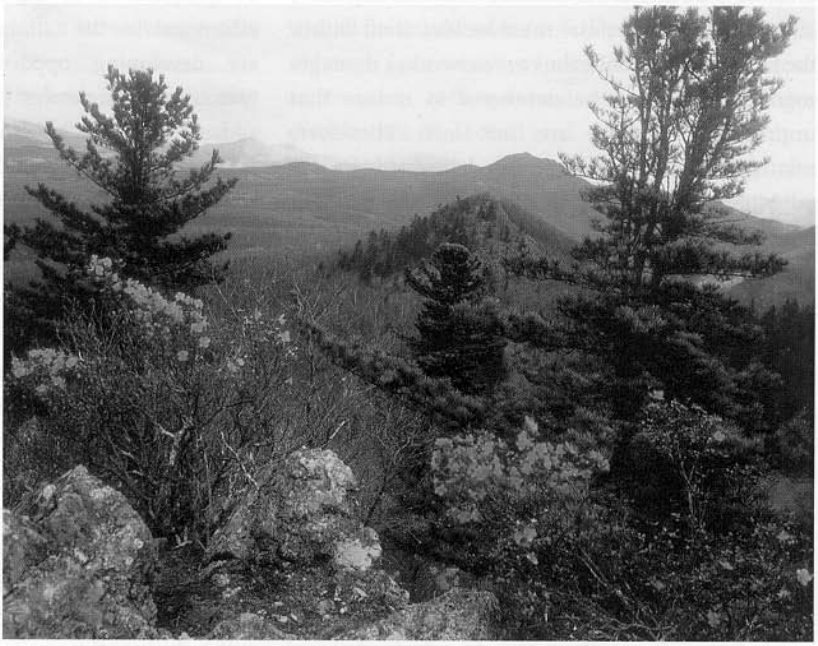
Define the planning process

For a habitat protection plan to be successful, we propose that it should have well-defined goals, that key components must be delineated from the start, and that criteria must be delineated to guide the process. Furthermore, it must be politically viable, i.e. there must be a reasonable chance of such a plan being implemented, and it must be biologically sound, i.e. it must be based on an understanding of key ecological parameters of tiger biology that are relevant to land-use planning and population dynamics. We review definition of our planning goal, define key components and determine the criteria we employed as a basis for developing this plan.

Define the goal

We defined the goal of this habitat protection plan as protection of all existing tiger habitat, i.e. no further loss of Amur tiger habitat should occur. We focused on managing the Russian Far East Amur tiger population as the last viable wild population of this subspecies (see 'Determine political criteria to guide the planning process political criteria' below). However, we focused on habitat protection instead of population management as the key mechanism to long-term survival. Definition of conservation units of land is 'more concrete', more specific and less politically and biologically debatable than definition of population goals. We did not attempt to define a target tiger population for the Russia Far East because:

1. Existing estimates were of unknown accuracy, and surveys in general have low resolution. When we initially developed this plan in 1995 (Miquelle *et al.* 1995), the best estimates for remaining tigers in the Russian Far East ranged from 250 (Pikunov 1990) to 338–350 (Mescheryakov & Kucherenko 1990), but the true number of tigers was a topic of heated debate. Given the uncertainty associated with tiger surveys in general (Karanth 1987), we felt it inappropriate to focus on numbers of animals as an overall goal because there would be no way to



The goal of the Amur tiger habitat protection plan: no further loss of Amur tiger habitat should occur.

accurately determine when we had achieved our management goal.

2. Existing estimates may not adequately reflect the potential of existing habitat. Even if accurate population estimates existed, they might not indicate how many tigers could be supported on a given land base, if properly managed. Therefore, extrapolating the potential population based on existing information might result in an inaccurate estimate of the 'carrying capacity' of the habitat.

3. Our ultimate goal was the protection of habitat. Although the exact number of tigers was unknown, it was clear that the last remaining stronghold of habitat occurred in the Russian Far East, and that habitat degradation and fragmentation would be long-term threats. No matter what the present status of the population, an adequate habitat base will be the key to long-term survival. Therefore, we felt it critical to define as our goal no further loss of tiger habitat.

Define key components of the plan

To achieve this goal of no habitat loss, we propose that an effective habitat protection plan for Amur tigers should consist of three components.

1. *There must be a core area that consists of a network of conservation units.* Amur tigers require large tracts of land (Yudakov & Nikolaev 1987, see below). Therefore, it is politically unfeasible to include all tiger habitat in protected areas (see 'Determine political criteria to guide the planning process political criteria' below). However, a core network of conservation units with a high level of legal protection should guard against catastrophic events and minimise the effects of long-term habitat and genetic erosion. The protected areas network should: (1) provide for a minimum target population of tigers (see 'Determine biological criteria to define the adequacy of conservation units' below); (2) provide a 'source population', or a protected 'reservoir' out of which tigers can emigrate to areas where localised extinction may occur; (3) mimic the shape of the existing habitat to ensure continuity, i.e. because the existing tiger habitat is somewhat elliptically shaped on a north/south axis (Fig. 19.1), an effective network of protected areas should extend throughout, also in a north/south projection.

2. *All potential tiger habitat must be identified and included in the planning process.* The core network by itself provides for only a minimum number of tigers. To ensure survival of the entire population, management must be extended to non-protected

areas outside the core area. To achieve this objective, all potential tiger habitat must be identified within the study area. Outside the core network, a management regime must be developed to ensure that unprotected habitats are not lost. Therefore, management zones must be delineated for all potential tiger habitat, and for each management zone a set of management guidelines should be established to guide land-use practices. This process sets priorities on which areas are most important, and acknowledges that there are some areas not suitable for occupation by tigers.

3. *All important tiger habitat must be interconnected.* A system of ecological corridors connecting both protected and unprotected areas is essential to ensure viability of the tiger population. Connectivity of the entire population will avoid the impact of genetic impoverishment, reduce the probability of fragmentation and reduce the chances of localised extirpation of small, isolated subpopulations, resulting, eventually, in loss of the entire metapopulation.

Determine political criteria to guide the planning process

For any land-use conservation plan to be successful, there must be a high probability that it will be politically viable. We attempted to assess the present political situation in the Russian Far East, and delineated the following political criteria.

1. *Proceed with efforts at international cooperation, but develop a plan that provides for a secure population of tigers within Russia, independent of an uncertain international alliance.* Available information suggests that there are perhaps 12 tigers remaining in fragmented patches of habitat in northeast China (Ma & Li 1996), and an unknown but small number remaining in North Korea. Given the small number of tigers in adjacent countries, and the variable and relatively 'cool' relations among North Korea, China and Russia, it would be unrealistic to rely on an international plan. Survival of the Amur tiger should not depend upon close political alliances between these three countries. A plan for tiger conservation in Russia should provide the opportunity for collaborative efforts, but should be designed to be effective and independent of efforts outside the national borders. Although there are developing opportunities for co-operative conservation measures (Anon. 1996d), we do not address that issue here; our premise is that there is minimal habitat left in China and perhaps Korea, and that Russia must develop a sustainable plan for conservation of the tiger independently.

2. *Rely on existing legislative precedence and existing plans for protected areas wherever possible for creating a protected areas network.* Russia is reeling from political and economic chaos resulting from the dissolution of the Soviet Union and the gradual replacement of a state-driven, command economy by a free-market economy (Yergin & Gustafson 1995). In this political environment, it is difficult to develop the consensus necessary for the type of long-term planning essential for conserving sufficient habitat for tigers. Perhaps most importantly, during this period of financial crisis and political impasse, federal and regional administrations are unlikely to commit to establishment of any protected areas that do not already have some legislative precedent. Therefore, the ideal protected areas network would minimise the need for new legislation, and would use existing and proposed protected areas wherever possible.

3. *Much existing tiger habitat will remain outside strictly protected areas and may require some legislation for multiple-use lands to be managed for tiger conservation.* Tiger habitat represents about 75% of Primorski Krai (Matyushkin *et al.* 1996), and coincides with the area of highest human density in southern Khabarovski Krai. It would be politically impossible to achieve our goal – protection of all tiger habitat – by removing all tiger habitat from the resource base of the Krais and turning the lands into protected areas with limited or no human access. Therefore, a large percentage of tiger habitat will remain outside the core protected areas network. For this reason, a zoning process, as delineated above (key component 2), will have to be a political process. There is at present no adequate means of protecting tiger habitat outside conservation units, nor is there a legislative context to the concept of ecological corridors, which are a key component of

this plan. Therefore although we must attempt to minimise the need for legislative actions, some new legislation will be essential.

4. *Reduce reliance on state funds for maintaining tiger habitat.* Federal and regional funds for conservation efforts are minimal and many local politicians must generate hard currency income through international 'joint venture' business enterprises, many of which rely on natural resource utilisation and thereby conflict with natural resource protection. Politicians are less likely to support legislation for new protected areas without confirmed financial backing or a mechanism for reducing the need for federal and regional financial support. Therefore, multiple-use lands, which can generate their own funds, must be incorporated into land-use planning for tigers.

Determine biological criteria to define the adequacy of conservation units

A plan for preservation of tiger habitat must have a solid scientific basis. However, there is usually limited time and financial support for developing land-use plans for tigers. Therefore, it is usually necessary (as it was in our situation) to use available information at the time planning occurs. Four types of biological criteria were necessary for our planning process.

1. *Define potential tiger habitat.* To delineate tiger habitat, it was first necessary to define what tiger habitat is. We used two primary criteria for defining potential tiger habitat: land ownership and cover type. Nearly all lands in Primorski and Khabarovski Krais fall into one of four land ownership/use categories: settlements, agricultural production, forest service and zapovedniks, or reserves (forest resources on zakazniks, or wildlife refuges, and national parks are administered by the Forest Service). Although much land managed for agricultural production is forested, we did not include it as potential tiger habitat because its primary use is contrary to tiger conservation, and there would be little chance of affecting future land-use decisions. Therefore, we included only those lands managed by the Russian Forest Service, and zapovedniks, which are managed under the State Committee for Protection of the Environment. We did not assume that all these lands were actually inhabited by tigers, although later analyses have demonstrated a close relationship between land ownership and tiger distribution (T. Merrill *et al.* unpubl. data). Rather, we assumed that these land categories had the potential to sustain tigers, and hence should be incorporated into the planning process. Within these regions, we used a 1968 forest-cover map (scale 1:2 500 000; Grebovoy *et al.* 1968) to define potential tiger habitat. The forest classification system for this map incorporates a variety of robust variables that define geobotanical potential and represent a description of enduring ecosystems, thus reducing the importance of the time interval between date of creation and the present. Using this cover map, we excluded all alpine and subalpine vegetative types, as well as high-elevation spruce-fir forests on Forest Service and zapovednik lands, because deep snows prohibit use by tigers (Matyushkin *et al.* 1996). All other forest types on these two land categories were included as potential tiger habitat.

2. *Define population goals within the protected areas network.* As noted above, we did not attempt to define a target tiger population for all tiger habitat. While the overall goal focuses on total land base, there has to be a rationale guiding the development of a protected areas network, and a decision base for determining how much land was required.

We defined the objective within the core network of protected areas as a population of 50 resident adult females. We focused on adult resident females as a basis for planning because they are usually the critical component of a population. Female reproductive parameters (litter size, age of first breeding, interval between breeding, breeding longevity) are often key demographic factors affecting viability of a population (e.g. see Beier 1993; Tilson *et al.* 1994), and an 'Allee effect', whereby animals at low density would have difficulty finding mates (e.g. Beier 1993), is not likely to be a problem with the present distribution of Amur tigers. We did not conduct a rigorous minimum viable population analysis, partly because many of the variables necessary for accurate projections are poorly known.

We used the value of 50 breeding females as a basis for planning with the following three justifications. First, conservation genetics suggests that an effective population size of 50 adult breeding animals is required as a minimum to prevent short-term genetic deterioration (Soulé 1980; Frankel & Soulé 1981). We did not have the necessary information to estimate effective population size, but data from Indian tigers suggest that effective population size is significantly smaller than actual population size (Smith & McDougal 1991); thus the need for a population of females considerably larger than 25 (half the suggested minimum adult population). Secondly, in general, genetic variation is related to population size (Frankham 1966), and therefore, 'the larger the population, the better'. However, thirdly, Amur tigers require large tracts of land (see below), and a population of even 50 females would require a massive network. Therefore, a qualitative 'middle' position for this core population was to ensure 50 resident adult females, thereby ensuring that it would be greater than the suggested minimum effective population size, but not so large as to be politically non-viable.

We emphasise that this core population is not considered to be a minimum viable population, and that this core population is not intended to be the only component of a habitat protection plan. This core network represents that segment of lands within existing Amur tiger habitat that would receive the highest level of protection, and should act as a buffer against catastrophic events (e.g. poaching episodes or extremely severe winters).

3. *Define criteria to estimate potential tiger population size within protected areas.* We propose that land-use planning for tigers should be based on defining the number of adult resident females that can be protected within existing or proposed conservation units. By knowing the area required by an average resident adult female tiger, it is possible to estimate the number of resident adult females that may occur within protected areas. This process provides a mechanism for determining the potential population size within any proposed conservation unit.

We propose that two key ecological parameters must be known to employ this approach: (1) home range size of adult resident females; and (2) social structure (or land tenure system). Average home range size delineates the amount of land required by an individual resident female, and an understanding of the social structure will determine the amount of overlap among resident females. These two parameters can be used to estimate the number of resident females that can 'fit' into a prescribed conservation unit.

Results of our research efforts in Sikhote-Alin Zapovednik indicate that the average home range size of five resident females was approximately 470 km^2, based on a 100% minimum convex polygon (MCP) estimator, or 350 km^2 based on a 95% MCP estimator (Miquelle *et al.* in prep.). Overlap between adjacent resident females averaged less than 4%, using the 95% MCP estimator, and approximately 15% overlap using the 100% MCP (Miquelle *et al.* in prep.). Based on this analysis, we believe that adult female tigers in Sikhote-Alin Zapovednik are territorial (i.e. maintain exclusive home ranges). An intensive snow-tracking study elsewhere in Primorski Krai also suggested that resident female Amur tigers have exclusive home ranges (Yudakov & Nikolaev 1987).

We believe that while the 95% MCP estimator probably provides a better representation of the ecological requirements of adult female tigers, the 100% MCP is a more conservative and more appropriate estimator for large-scale planning. Although there is more overlap in adjacent home ranges using the 100% MCP estimator (suggesting less land per individual would be required), much land included in a large-scale planning project would be unsuitable tiger habitat. Areas with high human disturbance, high-elevation forests, alpine and subalpine communities, or any habitats that contain few prey are unlikely to hold resident females, but would be included in low-resolution, large-scale planning (the 1:2 500 000 map used to identify potential tiger habitat will not identify many small patches of unsuitable habitat). Using the larger estimator, and still assuming exclusive territoriality, we provide a conservative estimate of the number of females that could use a given landscape.

Our comparison of projected estimates based on these criteria with the estimated number of adult females in Sikhote-Alin Zapovednik (E. N. Smirnov & D. G. Miquelle this volume) indicates that this estimator is reasonable, at least within one conservation unit.

Not all protected areas included in a network would be of equal value. A protected areas network will include conservation units that vary in level of legal protection (and therefore the extent of human impact), and in inherent environmental parameters that affect habitat quality. To account for variation in habitat quality and extent of human impact, we adjusted the estimated potential number of resident females in a conservation unit by a crude index that compared the quality of habitat to the best existing habitat in the Russian Far East. Large, well-protected zapovedniks (e.g. Sikhote-Alin, Lazo and Ussuriysk) received the highest ranking. The relative density of resident females in other areas was adjusted in 25% increments that provided an index of their relative value in comparison to zapovedniks.

4. *Define ecological corridors.* In general, suitable data to adequately define what constitutes an ecological corridor is lacking (Shafer 1990), and represents an especially difficult issue for large carnivores (however, see Beier 1993, 1995). In the Russian Far East, along the 1000 km linear distance of tiger range, corridors will by necessity be long, as they must provide connections between conservation units that will be great distances apart. Therefore, corridors must not only provide for the opportunity for tigers to briefly pass through a region, but must be large enough to sustain prey populations. Tigers should be able to live for extended periods of time, if not indefinitely, within designated corridors. This is a more conservative, broader definition, including larger land areas, than has been proposed for cougars (Beier 1993), and reflects the large scale of planning required for Amur tigers.

We consider corridors to be a specially designated land zone (see 'Determine political criteria to guide the planning process political criteria'), and therefore they have a political as well as ecological context. Because they must be areas where tigers could live indefinitely, we delineated corridors to be, on average, at least equal to the minimum diameter of female tiger home ranges. In Sikhote-Alin, the average minimum width of the 100% MCP of adult resident females was 16.5 km (D.G. Miquelle unpubl. data.). We sought to designate corridors that maintained this width criteria.

Implement the planning process

We employed an incremental, six-step process in delineating a habitat protection plan. We first focused on developing a protected areas network using the goals, key components and political and biological criteria delineated above, and secondly suggest a zoning process for the remaining tiger habitat. This stepwise process uses the political criteria to delineate the sequence of inclusions to a protected areas network, uses the biological criteria to define how many tigers could be protected, and at the same time ensures that adequate linkages exist between conservation units. Finally, we used large-scale (low-resolution) mapping data to define all potential tiger habitat (see 'Determine biological criteria to define the adequacy of conservation units'), and suggest a zoning process for lands outside the protected areas network (see 'Determine political criteria to guide the planning process political criteria').

Step 1. Assess the adequacy of existing protected areas

Using the estimates of territory size for an adult tigress, and the known size of existing zapovedniks, we estimated the number of females occurring in existing protected areas (Table 19.1) to be at least 18 adult resident female tigers in approximately 10 500 km^2 of existing protected areas. This estimate fits well with separate estimates in existing protected areas (e.g. Matyushkin *et al.* 1996; E. N. Smirnov & D. G. Miquelle this volume). We rated two conservation units as having lower-quality habitat: Botchinski Zapovednik, which is at the northernmost boundary of tiger range along the coast in Khabarovski Krai; and Barsovy Zakaznik, which sustains severe human disturbance due to the presence of a military training site within its boundaries.

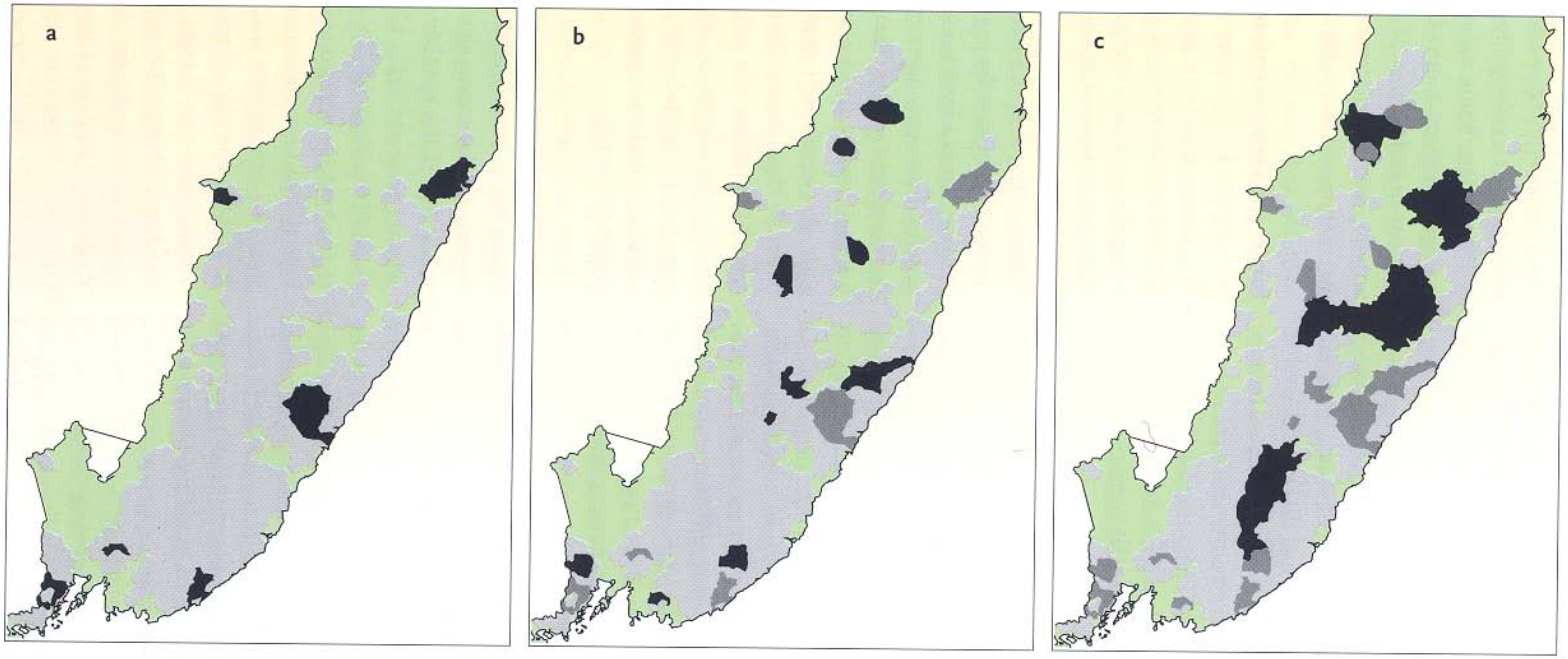


FIGURE 19.2

a. Step 1 in developing a protected areas network for the Amur tiger: assessment of existing protected areas (zapovedniks and key zakazniks) within potential tiger habitat, Russian Far East. **b.** Step 2 in developing a protected areas network for the Amur tiger: assessment of existing and proposed protected areas (zapovedniks and key zakazniks) within potential tiger habitat, Russian Far East. **c.** Step 3 in developing a protected areas network for the Amur tiger: assessment of existing and proposed protected areas (zapovedniks and key zakazniks), proposed and existing zones of traditional use, and multiple-use lands within potential tiger habitat, Russian Far East.

Not only does this estimate fall short of our planning goal for the number of females in a protected areas network (18 versus 50), but these conservation units are widely dispersed (Fig. 19.2a). Many are presently connected by existing forests, but there is no existing legal mechanism to ensure long-term connectivity. Therefore, we must increase the area of the network, and increase connectivity.

Step 2. Include regional and federal proposals for new protected areas that already have some legislative precedent

Incorporation of new lands into a protected areas network is substantially easier if there is some legislative precedent, or existing plans for protected areas (see 'Determine political criteria to guide the planning process political criteria'). Primorski Krai has developed a long-term plan for nature conservation sponsored by the Krai Administration (Yelyakov *et al.* 1993). Included are plans for three national parks, one nature park (Krai-level legislation), and one proposed zakaznik that would add significant lands to a tiger protected areas network. In Khabarovski Krai, one national park and three zakazniks have been proposed that are within tiger range. In total, creation of these conservation units would increase the total protected lands to over 26 000 km² (Fig. 19.2b). The relative gain in land area is not matched by relative gain in number of resident females, however, because the relative quality of these lands is less (Table 19.1). Nonetheless, this complex of lands would provide territory for an additional 23 resident females, bringing the total to approximately 42. However, there are still major gaps in the system that could lead to fragmentation in the future (Fig. 19.2b).

Step 3. Include multiple-use areas – proposed or existing – where tiger management will be a primary consideration

In an attempt to avoid the need for proposing new protected areas (see 'Determine political criteria to guide the planning process political criteria'), we assessed the feasibility of including existing and proposed multiple-use areas as tiger conservation units. Two types of multiple-use areas could be potentially included in the network. There exist two large tracts of land with proposed and/or existent zones of traditional use for indigenous people under the Primorski Krai plan for nature protection (Yelyakov *et al.* 1993). These two areas, the Bikin and Samarga, represent the last unlogged basins in Primorski Krai. The middle Bikin River Basin (already gazetted as a zone of traditional use) represents some of the best unprotected tiger habitat in northern Primorski Krai, while the upper Bikin (proposed zone of traditional use) is lower quality tiger habitat except close to the river bottoms (Matyushkin *et al.* 1996). The other proposed zone for traditional use, the Samarga River Basin, has only recently been recolonised by tigers (Smirnov & Miquelle 1995) and is close to the northern boundary of tiger distribution along the coast (Matyushkin *et al.* 1996). Nonetheless, there is evidence of breeding females there (Smirnov & Miquelle 1995; Matyushkin *et al.* 1996).

Traditional-use zones are open to hunting and potentially other extractive processes, thus decreasing their potential value for tiger conservation. However, indigenous people traditionally have a respect for tigers, and formerly did not hunt them (Arseniev 1941). Just as importantly, traditional-use zones represent large conservation units that protect habitat with little administrative cost associated with tiger conservation.

There are two international multiple-use planning projects within Amur tiger habitat. The United States Aid for International Development (USAID) Environmental Policy and Technology Project is developing a multiple-use plan for Chuguevski Raion, the centre of Primorski Krai, which has, as an explicit component of the plan, development of an 'ecological corridor' to link protected areas in the south (Lazovski Zapovednik) with those in the north (Sikhote-Alin Zapovednik) (USAID 1995). A series of protected zones and management of ungulates species have been incorporated into the planning effort. The Chuguevski Multiple Use Plan is important because: (1) it covers a large territory (7680 km²); (2) it is the first attempt in the Russian Far East to incorporate all user groups into a single planning effort; and (3) it incorporates endangered species and game species

Table 19.1. *Summary of proposed network of protected areas for Amur tigers in Primorski and southern Khabarovski Krais, and an estimate of potential density of adult female tigers in each conservation unit. See also Fig. 19.3*

Conservation unit	Status[a]	Area (km^2)	Relative density[b]	No. adult female tigers
Khabarovski Krai:				
1. Manominski Ecological Corridor		2078	0.25	1.1
2. Annui National Park	proposed	3000	0.5	3.2
3. Gassinski Model Forest	active	3800	0.25	2.0
4. Tigrini Dom Zakaznik	proposed	1500	0.75	2.4
5. Khor-Mykhen Ecological Corridor		4684	0.25	2.5
6. Chuken Zakaznik	proposed	2000	0.5	2.1
7. Matei Zakaznik	proposed	2000	0.75	3.2
8. Botchinski Zapovednik	1995	674	0.5	2.8
9. Bolshe Khetkhsirski Zapovednik	1963	451	1	1.0
North Primorye:				
10. Samarga Traditional Use Zone	proposed	4000	0.25	2.1
11. Samarga Ecological Corridor			0.25	0.0
12. Upper Bikin Zone of Traditional Use	proposed	6500	0.25	3.5
13. Bikin Zone of Traditional Use	active	6000	0.5	6.4
14. Kema Ecological Corridor		52	0.5	0.1
15. Kema-Amgu National Park	proposed	3000	0.75	4.8
16. Sikhote-Alin State Reserve	1935	4000	1	8.5
17. Central Ussurka National Park	proposed	1059	0.75	1.7
18. Central Zakaznik		282	0.5	0.3
Central Primorye:				
19. Dalnyegorsk Ecological Corridor		7145	0.25	3.8
20. Chuguevski Planning Project	in process	7680	0.5	8.2
21. Upper Ussuri National Park	proposed	971	0.75	1.5
South Primorye:				
22. Lasovsky Ecological Corridor		390	1	0.8
23. Lasovsky State Reserve	1935	1200	1	2.6
24. Nature Park Ecological Corridor		834	0.75	1.3
25. Southern Primorye Nature Park	proposed	715	0.5	0.8
26. Southern Sikhote-Alin Ecological Corridor		1180	0.5	1.3
27. Ussuri State Reserve	1932	404	1	0.9
Southwest Primorye:				
28. Borisovkoe Plateau Zakaznik	1996	613	1	1.3
29. Kedrovya Pad	1916	180	0.75	0.3
30. Barsovy Zakaznik		974	0.5	1.0
Totals		69366		71.5

[a] date of creation, officially proposed, or, if blank, newly proposed.
[b] relative index of habitat quality for tigers.

into the planning process. Tiger densities will be considerably lower in this region than in protected areas, but the process represents an attempt to include endangered species such as tigers into a land-use plan, an important precedent for Amur tiger conservation.

At the northern fringe of tiger range, there exists a Canadian-financed Gassinski Model Forest

Table 19.2. *Summary of land use categories for proposed protected areas network, and percentage of total land base of each administrative unit*

Land use category	Primorye		Southern Khabarovsk[a]		Total		
	Area (km^2)	% of area	Area (km^2)	% of area	Area (km^2)	% of admin. areas	% of network
Existing zapovedniks	5784	3.5	3125	3.1	8909	3.3	12.8
Existing zakazniks	1869	1.1	0	0.0	1869	0.7	2.7
Existing multiple-use zones	0	0.0	3800	3.8	3800	1.4	5.5
Existing ethnographic zones[b]	6000	3.6	0	0.0	6000	2.3	8.6
Proposed national parks	5745	3.5	3000	3.0	8745	3.3	12.6
Proposed zakazniks	0	0.0	5500	5.5	5500	2.1	7.9
Proposed ethnographic zones	10500	6.3	0	0.0	10500	3.9	15.1
Proposed multiple-use zones	7680	4.6	0	0.0	7680	2.9	11.1
Proposed ecological corridors	9601	5.8	6762	6.7	16363	6.1	23.6
Total	47179	28.4	22187	22.1	69366	26.0	100

[a] Southern Khabarovsk includes Bikinski, Vzyamski, Lazo, Khabarovski, Sovganski, Nanaiski and Komsomolski Raions.
[b] Ethnographic zones of Khabarovski Krai are not included in this assessment.

Project (Anon. 1996d). To a lesser extent, this project also includes endangered species in its management plan. Tigers do occur within the model forest, but, at the northern limits of tiger distribution, there are few breeding females in the area.

As multiple-use areas, these regions would not receive the level of protection allocated to other conservation units within the plan, and will not maintain the same density of tigers. However, inclusion comes with little additional political, financial, or administrative burden. Cumulatively, although the relative quality of the areas for tigers is less, inclusion of these lands means that the goal for a protected areas network is exceeded, with an estimated 59 resident females occurring on 52 000 km^2. Just as importantly, inclusion of these lands has filled many of the large 'gaps' between existing and proposed protected areas. Linkages, however, are still necessary (Fig. 19.2c).

Step 4. Propose new protected areas if necessary

Due to political inertia and the additional financial burden, we believe that proposals for new protected areas should be developed only when all existing and proposed protected areas and all multiple-use lands have been assessed and included in the planning process. At this point in our planning process, 8% of Primorski Krai is allocated to existing or proposed protected areas (zapovedniks, zakazniks, and national parks), and nearly 10% to zones of traditional use (Table 19.2). In southern Khabarovski Krai, 11.6% is allocated to existing or proposed protected areas (Table 19.2). Ethnographic zones, common in southern Khabarovsk, are not included in the assessment due to differences in legislative context of this land-use designation. In total (i.e. including multiple-use zones), 26% of the land base has been proposed for incorporation into the conservation network for tigers. Although less than 10% would be strictly protected (i.e. the other 16% would support human activities), proposals for new protected areas for tigers are unlikely to be politically viable. At the same time, we have exceeded our goal of 50 resident females. Therefore, we make no new proposals for protected areas, but seek to ensure that connections exist between all conservation units.

Step 5. Ensure connectivity

To prevent fragmentation, we attempted to link all existing components of the proposed network with

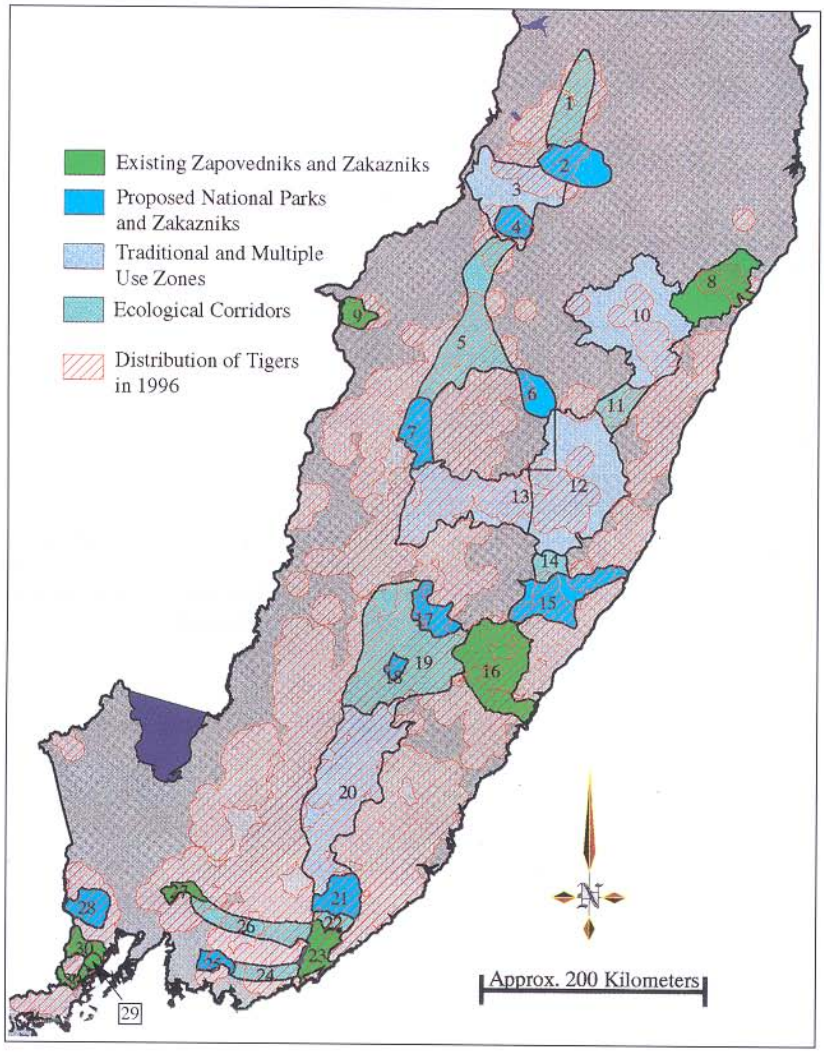


FIGURE 19.3
Step 5: A protected areas network of 30 conservation units connected by ecological corridors (except for southwest Primorye and Bolshekhetskhirski Zapovednik) for the Amur tiger in the Russian Far East. Numbers for conservation units are referenced in Table 19.1.

ecological corridors. This was possible in a north/south axis because forest cover is still intact throughout the Sikhote-Alin Mountain Range (Fig. 19.3). However, the development corridor between Vladivostok and the city of Ussuriysk makes restoration of a corridor linking the Sikhote-Alin and East Manchurian Mountains unlikely biologically and politically.

In total, 69 366 km², or 26% of the land base, is included in a network of conservation units (Table 19.2). This network would protect approximately 70 resident females, far exceeding our numeric goal, but not quite meeting the criteria for connectivity. There still exists a fragmentation point separating southwest Primorye and the Sikhote-Alin system (Fig. 19.3), but the network does protect a continuous band of tiger habitat along 900 km in a north/south gradient.

Step 6. Identify unprotected areas for inclusive tiger management plan

Once the network of protected areas had been identified, we used the potential tiger habitat map to identify all regions that could sustain tigers that

Table 19.3. *Allocation of lands in Primorye and southern Khabarovski Krais, Russian Far East, to protected areas network, unprotected potential tiger habitat, and percentage of lands presently inhabited by tigers in protected areas network and unprotected potential habitat*

	Within administrative region			Within protected area network			Outside protected area network			
Administrative Region	Total area	Total forested area[a] (km^2)	Potential tiger habitat[b] (km^2)	Potential habitat with tigers[c] (%)	Total protected network (km^2)	Portion of admin. unit (%)	Area with tigers[c] (%)	Potential tiger habitat (km^2)	Portion of admin. unit (%)	Area with tigers[c] (%)
Primorye	165 900	118 803	91 265	82.0	47 179	28.4	75.6	70 589	42.5	73.3
Southern Khabarovski	100 449	73 156	36 428	48.0	22 187	22.1	64.7	31 012	30.9	37.0
Total	266 349	191 959	127 693	65.0	69 366	26.0	70.2	101 601	36.7	55.1

[a] GosLesFund (Forest Service) lands and zapovedniks.

[b] GosLesFund and zapovedniks minus unsuitable tiger habitat (alpine, subalpine, swamps, and spruce-fir forests).

[c] Based on 1996 winter census (Matyushkin *et al.* 1996).

were not incorporated in the network. A total of 91 265 km^2 of Forest Service and zapovednik lands representing 55% of Primorski Krai, and 36 428 km^2 of forest lands in southern Khabarovski Krai (36%) were identified as potential tiger habitat. A significant portion of tiger habitat is outside the protected areas network (Table 19.3).

All tiger habitat outside the protected areas network must be included in a habitat protection plan for tigers. It is beyond the scope of this chapter to fully develop this component, but we offer a brief outline of key components of a plan for non-protected lands.

We recommend development of a zoning system for all of Primorski Krai and southern Khabarovski Krai. Zoning systems have been applied successfully for other large carnivores (e.g. Mech 1977). Because tiger habitat represents such a large percentage of these administrative units, it is important to incorporate the entire region, even areas considered unimportant to tigers. The objective of a zoning plan is to identify all areas important to tiger conservation, and then apply specific guidelines for managing those areas. Such a zoning process would accomplish several critical management tasks:

1. Identify all important tiger habitat, and provide an index of relative importance with a zoning system.
2. Identify all regions considered unacceptable for tiger habitat, and develop applicable management actions when tigers are located in such areas.
3. Provide management guidelines for each zone as minimum standards for tiger conservation.

We recommend that specialists familiar with specific regions of tiger habitat develop recommendations for a zoning plan, based on their knowledge of the region, and existing information on past and present tiger distribution (Yudakov & Nikolaev 1973; Pikunov & Bragin 1987; Matyushkin *et al.* 1996). We propose that three to five zones be created, ranging from areas deemed unacceptable for tigers (e.g. forest patches within village and city limits), to regions where protection of tigers is one of the highest priorities of land use. Each zone that includes tiger habitat should have an associated set of management guidelines. We suggest that management guidelines include recommendations for:

1 Type and extent of human activity allowed.
2 Type and extent of logging activity allowed.
3 Amount of hunting allowed, or target densities of key ungulate species.
4 Restrictions on road development, and road closures where possible.
5 Restrictions on development activities.

The importance of some of these variables to the Amur tiger population has been discussed elsewhere (Miquelle *et al.* 1993, 1995, D. G. Miquelle *et al.* this volume chapter 6). We believe that these human activities all have important impacts on tiger densities within potential tiger habitat and, at the same time, are manageable activities on Forest Service lands.

Assess the potential effectiveness of the plan

Ideally, an assessment of the potential effectiveness of a land-use plan should be conducted. Our land-use plan is based on the assumption that existing protected areas are quality tiger habitat, but that most forested lands have the capacity to sustain tigers. However, it was not clear what percentage of the proposed protected areas network actually contained tigers, or how distribution of tigers within the network compared to the total distribution of tigers, i.e. was the proposed network of protected areas better than a random selection of potential tiger habitat?

A complete survey of existing tiger habitat in 1996 (Matyushkin *et al.* 1996), initiated shortly after development of this plan, provided an opportunity to assess its effectiveness in comparison to the known distribution of tigers.

For approximately three months in the 1995–1996 winter census, tracks of tigers were reported on 652 count units distributed throughout approximately 90% of potential tiger habitat. Field counters plotted out the location of each track on 1:100 000 maps. A geographic information systems (GIS) database was created with this information, and we generated a distribution map of tigers by encompassing each track with a 10-km radius circle, representing the approximate minimum diameter (see above) of female home ranges (Yudakov & Nikolaev 1987; D. G. Miquelle *et al.* unpubl. data).

The results of this process suggested that tigers occurred on 82% of potential habitat in Primorski Krai and only 48% of Khabarovski Krai. Overall, tigers occurred on 70% of lands inside the protected areas network (including lands that were not classified as potential habitat), but only on 55% of potential habitat outside the network (Fig. 19.4; Table 19.3). These results suggest that the protected areas network is more effective than a random selection of potential tiger habitat, but the differences are not great. There appear to be two reasons for the relatively minor differences:

1 Much of the land within the network is composed of proposed protected areas, or proposed multiple-use/ethnographic zones. Without adequate protection currently in place, it is not expected that these lands would presently have a tiger density higher than average. The recent survey clearly indicated that protected lands had higher densities of tigers (Matyushkin *et al.* 1996). We predict that if proposed protected areas received an adequate level of protection, density of tigers would increase.
2 Some areas included in the network are unsuitable habitat for tigers. This is particularly true of the ethnographic zones, which include large tracts of spruce-fir and larch forests, which are poor quality habitat for Amur tigers. These tracts are retained in the plan because they maintain connectivity of habitat, and there is little political/administrative cost in incorporating them into a tiger conservation plan. However, it must be recognised that such lands will hold few resident tigers.

Discussion

We initiated our research with the objective of obtaining the necessary information for formulation of a conservation plan, and were fortunate to

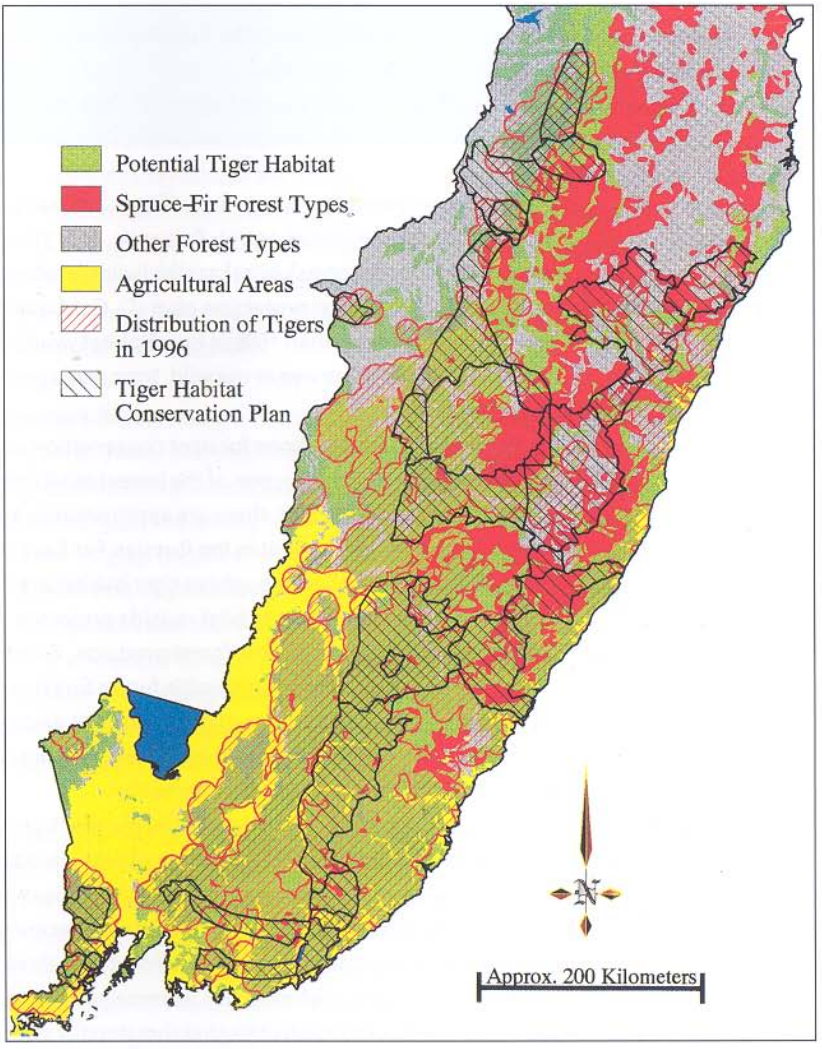


FIGURE 19.4
Distribution of tigers, based on a 10-km radius of tracks located during the 1996 winter census (Matyushkin *et al.* 1996), in comparison to the proposed protected areas network, and identified potential tiger habitat.

have a sufficient database when a federal decree ordered development of just such a plan. We were able to use the 'high-resolution' data on ecological parameters of Amur tigers, combined with 'low-resolution', large-scale data for forest cover, tiger census data and administrative units to develop a biologically and politically defensible land-use conservation plan for tigers. During a workshop in September 1995 to formulate a national strategy for tigers, we were able to present our proposal to the federal government for consideration (Miquelle *et al.* 1995). As a result, the basic concept for a protected areas network and a zoning plan for tigers was incorporated into the national strategy document (State Committee of the Russian Federation for the Protection of the Environment 1996). We believe that this is a valuable lesson of the need for research that addresses conservation issues, and of the value of applying ecological data to the formulation of federal policies for natural resource management.

Planning is a process, and often it is necessary to initiate that process with inadequate information. We are moving forward with continued research on

Box 19.1 People and tigers in the Russian Far East: searching for the 'co-existence recipe'

Dale G. Miquelle and Evgeny N. Smirnov

There is approximately 156 000 km² of tiger habitat remaining in the Russian Far East (Matyushkin *et al.* 1996). Presently, only 7% of this area is protected as zapovedniks (reserves) or zakazniks (wildlife refuges). Even under the most optimistic habitat protection plan (D. G. Miquelle *et al.* this volume Chapter 19), no more than 16% of tiger habitat would be strictly protected. If the Amur tiger is to survive in the wild, tiger management cannot be restricted to nature reserves.

Perhaps the greatest hope for tiger conservation in Russia is the low human population density; one of the lowest in all range countries at between 1 and 14/km². Nonetheless, there are approximately 3.9 million people living in or adjacent to tiger habitat in the Russian Far East. While 80% of these are urban dwellers, villagers throughout tiger habitat are dependent on forest resources. Virtually all tiger habitat outside protected areas is exploited for timber, wildlife and non-timber forest products. Given the present economic instability in Russia, in the foreseeable future forest resources will be viewed by administrations as a source of hard currency, and by local villagers as a source of food, raw materials and livelihood. Halting natural resource exploitation is not an acceptable alternative.

It is clear, therefore, that a successful plan for tiger conservation in the Russian Far East will combine a system of protected areas with a management regime in unprotected lands that gives high priority to tiger conservation. Thus the need for a co-existence recipe on unprotected lands. The search for this co-existence recipe must first identify potential points of conflict – situations in which tigers adversely impact humans and arouse animosity, and human activities that threaten the tiger's existence – and then seek solutions. Some conflicts, such as competition for prey, impose mutual adverse impacts.

Adverse impacts of tigers on humans

Loss of human life Although early accounts suggest that attacks on Man in Manchuria and Russia were not uncommon (Prezhewalski 1870; Baikov 1925), since 1970 attacks have been exceedingly rare (Nikolaev & Yudin 1992). Although meetings with tigers are common (e.g. Smirnov 1997), there have been only six cases of unprovoked attacks and man-eating since 1970, and in only one case have there been repeated attacks (two) by one tiger. Provoked attacks (usually the result of hunters wounding tigers) have occurred more frequently. Provoked or not, all interactions with tigers resulting in human death receive inordinate attention from the local press, while the daily

shootings in Vladivostok go virtually ignored. Presently, all such incidents are investigated by state-employed specialists; permits to kill culprit tigers are usually issued to state officials where evidence suggests unprovoked attacks, or where severely wounded tigers pose future threats. Some education programmes may reduce the number of such incidences, but as long as tigers and Man co-exist this conflict will never be completely eliminated. Man-killing tigers, though rare in Russia, are bad publicity and hurt tiger conservation efforts. Long-term success may depend on demonstration to local people that their voice is also heard: problem animals must removed from the wild quickly and professionally.

Livestock depredation Depredation on livestock has increased throughout the last 50 years, coincident with an increasing tiger population; 30 depredation incidences (cattle and horses) were reported in Russia between 1920 and1940, 102 during 1941–1960, and 362 from 1961 to 1970 (Yudakov & Nikolaev 1973). Detailed recent records are unavailable, but evidence suggests that this trend is decreasing (Miquelle *et al.* 1996b). Depredation is often episodic and short-lived; nonetheless, local small-time farmers cannot bear the financial burden. Resolution of this situation will depend on an adequate natural prey base as well as compensation. Locally financed, self-sustainable 'insurance' programmes for farmers may help alleviate the economic loss and reduce animosity.

Competition for prey In a survey of hunters, over 55% were either neutral or agreed with the statement that tigers are a problem because they kill too many ungulates. The wildlife management system in Russia allocates specific territories to an individual or group, which is then responsible for proper management with harvests at a level appropriate for the game numbers within that unit. Hunters often complain that tigers are removing prey that could have been included in their quota. While scientific research may demonstrate that tigers do not regulate prey or impact prey densities, personal convictions are often stronger than any hunter education programme. Working with local hunting groups to reduce poaching, to improve habitat conditions for ungulates, to improve hunters' economic status and capacity for self-management, and to increase their sense of ownership of and responsibility for wildlife resources – all activities that should increase prey populations – is beneficial both to hunters and to tigers. Model programmes based on this premise are promising. Ultimately, hunters must see some benefit in 'carrying the burden' of the tigers inhabiting their hunting unit; reduced license fees or other state-sponsored assistance must be forthcoming.

Adverse impacts of humans on tigers

Poaching Poaching is considered in detail elsewhere in this volume (S. R. Galster & K. V. Eliot). Ultimately, positive and negative reinforcements will both be necessary. Stiff penalties, high conviction rates of poachers, and a belief by potential poachers that capture is a distinct possibility must come in conjunction with long-term education programmes.

Timber harvest Logging is not incompatible with tiger conservation. Selective cutting of appropriate species and age-classes can actually improve tiger habitat in some situations. But not all logging is beneficial. A clear understanding of the complex relationship between logging and its impact on tiger habitat is yet to be fully delineated, but a concise description of logging regimes compatible with tiger conservation must be developed and incorporated into Russian Forest Service policy and enforcement guidelines.

Habitat destruction To provide for a viable population of tigers in the Russian Far East, all remaining habitat must be retained (D.G. Miquelle *et al.* this volume chapter 19). Any type of development that reduces tiger habitat in the region reduces the long-term chances of survival of this population. Existing state forest lands (GosLesFund) must be managed for long-term ecosystem integrity; and, if possible, easements to secure forested lands not included in GosLesFund should be developed.

Selective logging is compatible with tiger conservation, but the roads it leaves behind can make illegal access easier if steps are not taken to close them.

Road access Road construction is the Achilles heel of selective cutting, which in comparison to clear-cutting requires vast areas (and therefore a vast road network) to secure equal harvest volumes. A high-density road network provides easy access for all kinds of forest exploitation, and has severe impact on tigers and their prey through both legal and illegal hunting. Experimental road closures are now being developed in conjunction with programmes of assistance for hunting societies and agreements with local Forest Service officials. A large-scale programme for road closures is of the utmost importance to increase the extent of secure habitat for tigers and prey.

Many components of the 'co-existence recipe' in Russia have been identified in the national 'Strategy for Conservation of the Amur tiger in Russia'. Management regimes for other large carnivores (e.g. brown bears, wolves and mountain lions) from other countries can provide clues in seeking appropriate resolution mechanisms. However, ultimately realisation of the goals of the national strategy will depend on forthcoming results in two arenas. Within the federal and regional political arena, policy decisions must be made to enhance the potential for tiger survival. At a local level, 'grassroots' efforts must be focused on components of the 'co-existence recipe' that demonstrate feasible and positive benefits to local inhabitants as well as protection of tigers.

tiger ecology, and development of more detailed cover maps on land ownership, land use, road networks and forest cover. This information will be critical to refinement of a land-use plan for tigers. We believe it better to initiate the planning process even when perceived information needs are inadequate. Planning will always occur with some degree of uncertainty; therefore, it must be acknowledged from the start that planning is a process and that plans will change as experience and more information become available.

Acquiring 'high-resolution' data on tiger ecology requires intensive fieldwork and substantial financial investment, and will not be possible in all tiger range countries. Therefore, the process of using ecological parameters to determine the adequacy of protected areas in other range countries may be limited, unless reasonable estimates of those parameters can be inferred. 'Low-resolution' information on present tiger distribution, existing forest habitats, land ownership, land use and road networks are often available, or can be developed fairly rapidly. These geographic data layers are the key starting point to developing protected area networks, and can provide invaluable information in formulating and adjusting plans. For instance, we are presently using land ownership, land-use maps and forest-cover maps as indicators to identify potential fragmentation points in the Sikhote-Alin tiger population, and to search for potential linkages amongst Chinese and Russian habitat patches.

This proposed plan, which includes nearly 70 000 km^2, would represent one of the largest protected areas networks in the world, if implemented. For instance, it is comparable in size and scope to any of the Wildlands Projects (e.g. Noss 1993). The size of the network makes the process of implementation a daunting one. More daunting, perhaps, is the political and economic context in which implementation must occur. Russia's

political process is unstable and evolving on a daily basis, and the economic environment forces businesses to focus on maximising short-term returns. This is not a conducive atmosphere for long-term natural resource planning.

Nonetheless, there are four points that favour the process.

1 Perhaps most importantly, the human population density in the region is very low: 3.3 million people live in Primorski Krai, but 78% live in urban centres (Kungurova undated), while 80% of the 1.6 million people in Khabarovski Krai are urban dwellers (Pensen *et al.* 1995). The intense pressure on tiger habitat by the burgeoning populations of the Indian subcontinent, for instance, are not present in the Russian Far East; the density of people in tiger habitat (outside the urban centres) ranges from 0.1 to 3.5/km^2 (Kungurova undated; Pensen *et al.* 1995).

2 The Sikhote-Alin ecosystem represents a largely intact, continuous habitat for tigers. The highest-quality habitat for Amur tigers has already been lost to human development in China, Korea and Russia during colonisation phases and rapid human growth over the last century (Stephan 1994; Janhunen 1996). The remaining habitat is largely mountainous and unsuitable for intensive human exploitation. To date mineral exploitation has been localised, and the selective logging regime most commonly practised does not destroy tiger habitat (Miquelle *et al.* 1993).

3 Many components of the plan have already been proposed. We are not proposing a totally new set of recommendations to the federal and local administrations, but are mostly asking that the existing recommendations be implemented. A large percentage (46%) of the proposed network is comprised of proposed protected areas and proposed ethnographic territories. However, many of these proposed protected areas are in the process of being established (USAID Environmental Policy and Technology Project 1995; V. K. Berseniev pers. comm.).

4 Finally, tiger conservation can be compatible with other land uses. There needs to be a core area with a high level of protection, but well-managed resource extraction regimes can, in some instances, improve tiger habitat and, in many others, minimise potential impact.

There are many components of this plan that will require adjustments in the future. For instance, ecological corridors comprise 25% of the protected areas network, and are exceptionally long in some places, e.g. linking Ussuriyski Zapovednik and the proposed southern Primorye Nature Park (75 km); and linking Matei Zakaznik and Tigrini Dom Zakaznik in Khabarovski Krai (160 km). This concept of ecological corridors is quite different from the typical concept of a short linkage between distinct habitat patches (e.g. Beier 1993). Moreover, the whole concept of ecological corridors is new in Russian land-use planning. At present there is no legislative precedence to provide guidelines that would legally define what constitutes an ecological corridor, nor is it clear what exactly would be the management criteria for ecological corridors. Even within the proposal presented here, not all biological criteria were always met, e.g. minimum width criteria for ecological corridors were not maintained in all instances. Exact delineation of what constitutes corridors, and exactly where they will occur, awaits a detailed planning process conducted within each administrative region.

At the same time there are a myriad of legislative and political issues that must be addressed for full implementation. A large percentage (38%) of the network is comprised of proposed protected areas and proposed zones of traditional use. All these lands must undergo a tedious bureaucratic process for gazetting.

The value of the southwest Primorye lands to tiger conservation is debatable. At present, the population of tigers in this region is believed to be less than 10 (Matyushkin *et al.* 1966). By themselves, these protected areas are insufficient to

maintain a viable population of tigers. Therefore, two critical steps need to be taken in the near future: (1) assess the feasibility of reconnecting this fragment of habitat to the Sikhote-Alin ecosystem; and (2) assess the feasibility of creating international protected areas with China (Anon. 1996b). The potential exists in trans-boundary lands on both sides of the Sino-Russian border to connect southwest Primorye with another fragment of habitat in Pogranichny Raion near Lake Khanka, thus greatly expanding the potential habitat for tigers. This region also represents the last habitat for the Far Eastern leopard, a large cat subspecies even more endangered than the Amur tiger (Miquelle *et al.* 1996a). Therefore, focus on protecting this block of habitat is doubly important.

Although not presented in detail here, the implementation of a zoning process outside the protected areas network is just as important a step as the creation of a network itself. Here, challenges will be faced in delineating a zoning process for tigers that does not impede sustainable resource use, does not commit federal and regional administrations to undue financial burdens, and that can be accepted by the local populace. Finding an acceptable balance between tiger conservation, logging interests and hunting rights will be crucial tests in this arena.

The process of developing and implementing such a plan is long-term. We invested over five years to acquire an adequate database for development of a defensible habitat protection plan, which was then incorporated into the national strategy for tiger conservation. Now, there must be extensive and intensive efforts to implement the plan.