THE TECHNICAL ASSESSMENT

Setting Priorities for the Conservation and Recovery of

WILD TIGERS: 2005-2015

WILDLIFE CONSERVATION SOCIETY

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Smithsonian National Zoological Park Conservation & Research Center

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Executive Summary

Wild tigers are in a precarious state. Our best approximation concludes that tiger habitats throughout India, Indochina, and Southeast Asia are now 40% less than what we estimated in 1995. As the Economic Tigers of Asia leap onto the world stage, wild tiger populations in those countries are in steep decline; today tigers occupy a mere 7% of their historical range and the threats are mounting, rather than diminishing.

A world without tigers is hard to imagine, but red flags are being hoisted across the tiger's range. In India, poaching in what were thought to be well-protected Tiger Reserves has been so intense recently that it has become a national issue eliciting an investigation by a Prime Ministerial Commission. In Indochina, widespread poaching of tigers and wildlife continues to create empty forests, and the development of the proposed transnational economic corridors in the region will further fragment Indochina's remaining forests and create dispersal barriers. In Sumatra and Malaysia, vast oil palm and acacia plantations are predicted to result in complete conversion of some of the richest lowland rain forests on Earth, habitats that were populated by tigers only a few years ago. The increasing demand for tiger parts for folk medicines in China and Southeast Asia and for costume adornment among Tibet's growing middle-class has intensified threats to tigers across the range. Despite these setbacks, this is hardly the time for inaction or retreat. To paraphrase E. O. Wilson, tigers can't afford another century, or even another decade like the last one. Indeed, we must rededicate and galvanize our efforts to make tigers and tiger habitats a conservation imperative in the remaining landscapes of Asia.

Tigers are a conservation dependent species. They require protection from killing, an adequate prey base, and adequate habitat area. While the tiger as a species may not go extinct within the next two decades, the current trajectory will surely cause wild populations to disappear in many places, or shrink to the point of "ecological extinction"—where their numbers are too few to play their role as the top predator in the ecosystem. Therefore, now, more than ever, tigers need homeland security.

There are two possible strategies to ensure the future of wild tigers. One calls for securing a few tiger populations in increasingly isolated reserves while ignoring the retreat of forests outside. However, the natural history features of tigers—their need for large areas as top predators and their extreme territoriality—make this a poor option. The recent spate of killings in Tiger Reserves—regarded as the crown jewels of India's protected areas system—suggest that providing adequate protection to insular reserves is not enough.

A second approach—one which we endorse—is to create tiger landscapes, where core areas are linked with habitat corridors that allow the ecological requirements of wild tigers to be conserved as well. Such a strategy will require the support of the people living in the region. Although seemingly a difficult task, the successes of the Terai Arc Landscape Project being implemented in the foothills of Nepal and Northwestern India—in the midst of some of the densest human populations in South Asia—shows that creating corridors and eliciting the support of local people for tiger conservation is indeed possible. The successes are predicated on the reality that tiger conservation also results in conservation of ecological services that support and enhance local economies and livelihoods and so are in their self-interest. Another important aspect is to keep landscapes intact for tigers, best illustrated in the Russian Far East, which not only ensures the persistence of tigers into the future but leads to natural recolonization of neighboring areas, which has happened in China.

Large mammals, including tigers, have coexisted for centuries with dense human populations. The release of the 1997 Tiger Conservation Unit Analysis (TCU 1.0) identified where tigers can live in the future. During the decade since, experiences from implementing field conservation projects have confirmed that the future of wildlife conservation in Asia depends on judicious land use planning—zoning—of human use areas, core wildlife habitat, buffer zones, and corridors in large conservation landscapes to restore the harmony that once existed in the wildland-village interface of rural Asia.

This document, based on the concept of Tiger Conservation Landscapes (TCL 2.0), improves on the original analysis by: 1) compiling more accurate satellite imagery to improve mapping of potential tiger habitat; 2) building a new spatial database of tiger status and distribution; 3) incorporating new knowledge gained about tiger biology to create a standard for measuring the quality of tiger landscapes; 4) employing a systematic measure of human influence on tiger habitat (the "human footprint"); 5) automating the process of landscape delineation to make updates more rapid, rigorous, and transparent; 6) analyzing the sensitivity of results to assumptions made about tiger dispersal and minimum area size to support breeding tigers; and 7) updating priorities that move tiger conservation forward emphasizing representation and resilience. TCL 2.0 is truly a "living document" that has benefited from open peer-review and that can continue to guide conservation efforts into the future. To learn how the analysis was done in detail, please refer to "Setting Priorities for the Conservation and Recovery of Wild Tigers: 2005–2015. The Technical Assessment."

In this *User's Guide* (Dinerstein et al 2006) and the *Technical Assessment*, we highlight the remaining tigerlands—the large landscapes of habitat, often anchored by protected areas—that are Global Priorities for conservation. In order to go beyond the current state of tigerland, we also focus on those places where habitat restoration or improved conservation measures could bring tiger populations back from the brink of extinction. All are dependent on local, regional, national, and international support to sustain them, and must be integrated into national and regional resource and land management programs. Only such efforts can redirect the current downward trajectory to ensure survival of wild tiger populations. For this generation to deprive future generations of the chance to see or track a wild tiger or to hear its royal roar is a travesty.

We have identified 76 Tiger Conservation Landscapes (TCLs) across the tiger's current range (see map). Each landscape is classified into a "taxonomy" measuring their contribution to current tiger conservation and further prioritized in terms of their contribution to representation of tigers across the range. Global Priority landscapes were identified in all major biomes and bioregions where tigers occur. Investing in these global priorities will ensure conservation of not just tigers, but "tigerness," the suite of adaptations tigers have evolved to live in habitats as different as mangrove swamps and boreal forests.

Our results show that the Indian Subcontinent bioregion has the largest number of TCLs (40, of which 11 are of Global Priority). The Northern Forests of Nepal-India-Bhutan-Myanmar, Western and Eastern Ghats, Sundarbans, and the tall grasslands and riparian forests of the Terai Arc set the foundation for tiger conservation across a diverse array of habitats in this bioregion. Yet, this bioregion also has the most questionable habitats, where we were unable to assess or determine if tigers still do, or can, persevere in small, isolated habitat patches.

The Indochina bioregion supports 20 TCLs, but these account for the largest total area (~540,000 km^2) among the four bioregions, primarily because they represent vast swathes along the mountain regions of Myanmar and Thailand (notably the Tenasserim mountains range) and the Annamite Mountains of Laos and Viet Nam. Six are Global Priorities. The large areas of dry forest mosaics in Cambodia are likely the best such forest habitats for tigers across its range. Unfortunately tigers have largely been extirpated from many of the lowlands within this bioregion, and restoring tigers to these areas will require a sustained, long-term effort. Please note that TCL 37 spans both the Indian Subcontinent and Indochina bioregions and was intentionally double counted (thus included in the total number of TCLs in the Indian subcontinent and Indochina bioregion) due to the large amount of habitat present in both bioregions.

The Southeast Asia bioregion includes 15 TCLs, with three being Global Priorities. The latter are primarily in the montane regions, centered on Malaysia's Taman Negara National Park, and Sumatra's Kerinci National Park. In Sumatra's large Leuser ecosystem the status of tigers is unknown, but it overlaps with critical habitat for the orang-utan and Sumatran rhinoceros and has been designated as both a World Heritage Site and Man and Biosphere reserve, confirming the importance of this ecosystem to Sumatra's natural heritage.

The Russia Far East bioregion contains two TCLs, including the world's largest, which is 270,000 km^2. This TCL is primarily in Russia, but extends into northeast China, which has recently recorded tigers on its side of the border. Although this vast mixed temperate forest TCL has approximately 10% of its area under protection, the rest is unprotected wilderness in which the tiger is still able to persist. Rapid changes due to privatization and leasing of this forest to timber industries may constrain the future of the Amur tiger.

Our findings show that in each of the first three bioregions, the range of the tiger has contracted dramatically since 1995. Much of this change undoubtedly rests with changes in methodology and improvements in the underlying datasets, but it is also true that most of the signs we do have point to continuing declines in tiger habitat and numbers. How many wild tigers remain is impossible to know without systematic surveys across the range. Moreover our assessment is limited by the quality of available land cover maps, lack of range-wide measurements of prey numbers, our poor understanding of tiger dispersal, and incomplete information on other aspects of tiger biology. Though we understand tigers better than before, we still have much to learn.

Tiger conservation over the next decade will require building Tiger Conservation Landscapes into the development agenda of range states and regional plans, and we suggest several important areas for funding to define a holistic strategy, which includes:
1) recruiting global and regional spokesperson(s) of great stature to speak for tiger conservation, 2) mainstreaming tiger conservation into national and regional development plans, 3) making TCL 2.0 broadly accessible and actively promoting its conclusions within Tigerland, 4) continuing attention to curtailing the trade in tiger parts from TCLs, 5) issuing periodic, public report cards on the status of tigers in TCLs, 6) financing of case studies demonstrating how TCLs can be linked to ecosystem services and zoned as part of the entire resource management program in a country, and 7) continuing to advance the science of tiger conservation.

The same factors that endanger tigers could be brought to bear to save them if the politicalwill can be found. Asia's economic wealth creates new resources that can be invested in Asia's natural patrimony. And few species inspire an increasingly affluent, conservation-minded public like the tiger. Economic development depends on transboundary cooperation—so does tiger conservation.

Conservation of tigers will help conserve ecosystems and landscapes that provide human populations with essential ecological services to ensure necessities such as food and water, and for maintaining a high-quality environment for health and economic reasons; it is not just tigers, but people who require conservation in tigerland. We must act now, not just to preserve this awe-inspiring creature, but to ensure the health of ecosystems that also subsidize our own well-being.

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PROLOGUE

Whether the tiger is viewed with awe and fear because of its massive power, or admired for its flaming beauty, the shadowed presence of this great cat permeates the forests where it still endures, and echoes hauntingly in those forests from which it has recently gone extinct. The species has a small but worldwide core of persistent advocates concerned about its future, not only because of its sheer magnificence, but also as an icon of conservation, symbolizing the imperative of protecting all animals and plants within its realm. As this report points out, 93% of the tiger's original range has been lost in the past 150 years. And the decline in numbers and distribution continues. The situation is grave. On the Indian subcontinent, with the largest remaining tiger population, only 11% of original habitat remains, and the remainder is increasingly fragmented and often degraded. Tigers also face threats other than loss of habitat, competing with local communities for deer, wild pigs, and other natural prey. On the positive side, tigers are resilient and adaptable, needing only ample space, natural prey, cover, and water, and they are able to reproduce rapidly.

In 1997 the World Wildlife Fund and Wildlife Conservation Society, with financial and programmatic support from the Save the Tiger Fund, produced an important report that identified areas where tigers still lived or could live, and suggested various conservation initiatives to prevent the extinction of fragmented breeding populations. Much new information on status and distribution has become available during the past decade, various important ideas on how best to conserve tigers have broadened, and technological advances have greatly improved how data and ideas can be used to set conservation priorities. This new report, far-sighted in concept and elegant in analysis, offers timely and essential information. The approach to conservation amplifies the ecological focus of the original report on preserving tigers in their various distinct habitats from coastal mangroves and open woodlands to rain forest. The goal is to preserve whole landscapes with the cats managed in large tracts of habitat that include core areas, buffer zones, and dispersal routes.

The vision is grand, the task difficult and expensive—but essential. It involves gathering more knowledge at each site about tigers and their prey, as well as about the local communities; it requires realistic policies and laws; it means protecting key areas with a trained and active guard force; and, above all, it must have the involvement of local peoples who recognize the spiritual and cultural values of tigers and treasure an ecological integrity upon which their livelihood depends. India is currently debating whether to give land title to the many families that are settled within government forests. What long-term effect would this have on managing landscapes for tigers?

Too few investigators are in the field to collect ecological information, monitor wildlife, and actively resolve conflicts between tigers and people. However, knowledge alone will not assure the tiger's survival. It is a matter of sadness and apprehension that during the past several years, tigers in several of India's reserves have been decimated by poachers: Tigers have been wiped out in Sariska and Namdapha, and severely reduced in Panna and Ranthambore, to name just four reserves, in spite of a large guard force and much money for conservation. Tiger bones and hides are smuggled principally into China, the former for medicine and the latter to be worn by Tibetans as a statement of status and fashion.

Better international cooperation is necessary on issues such as this. A knowledge gap must be closed, as the report notes, but so too must a protection gap. Tiger habitat extends across national borders. Russia and China already collaborate in a trans-frontier effort at protection and management, as do Nepal and India, and a similar initiative is needed, for example, between China and India, Myanmar and India, Myanmar and Thailand, and among Laos, Vietnam, and Cambodia.

This thorough report provides compelling data that also represents a strong call for action. Priorities are clear and options still remain open in all tiger countries. In the final analysis, saving the tiger is a moral issue, an act of conscience, to which each country must make a sincere national commitment.

— George B. Schaller

Setting Priorities for the Conservation and Recovery of Wild Tigers: 2005-2015

The Technical Assessment

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Chapter 1 Introduction

1.1 Successes of the 1997 *Framework Document*

The conservation of wild tigers rests upon answering to two similar biological questions: What controls tiger populations? And what controls the probability of their persistence? The first question concerns the tiger's ecology and behavior; the second mixes ecology and human values. We need to know enough about the tigers' ecological needs to be able to conserve them and resolve the conflicts they face with people. The principal challenge conservationists face is how to prevail over short-term human interests that leave landscapes devoid of tigers.

With the publication of *A Framework for Identifying High Priority Areas and Actions for the Conservation of Tigers in the Wild* in 1997 (Dinerstein et al. 1997; hereafter TCU 1.0), conservation scientists and practitioners welcomed a new vision for saving tigers on their home ground. The Framework Document shifted conservation thinking from the tiger population as the total number of individuals in the whole species or subspecies, to identifying and focusing conservation attention on geographically distinct groups of tigers (subpopulations) between which there is little or no demographic or genetic exchange. It established as a primary goal, the conservation of "tigerness," the suite of adaptations tiger populations have evolved to persist across a wide array of habitats, from mangroves to montane forests, and feeding on prey assemblages as diverse as primates in lowland rain forests to takin and other high-elevation ungulates at timberline. This ecological approach to conserving tigers recognized the tiger's genetic distinctiveness across its range, but also behavioral, demographic, and ecological distinctiveness. It recognized the value of tigers as top predators in ecosystems and their role as umbrella species for conservation of other species and ecological processes.

Above all, TCU 1.0 indicated where tigers could live but had been extirpated, where wild tigers still roam, and where wild tigers might occur if we knew more about these areas. Tiger's once vast range spanned 70 degrees of latitude and 100 degrees of longitude from the Russian Far East south to Indonesia, and west to central Asia and the Indian subcontinent, south of the Himalayas. The maps of actual and potential tiger distribution in TCU 1.0 demonstrated the severe fragmentation and drastic reduction of space where this largest of the cats once ranged or could still persist. Apart from their primary distribution, tigers once lived adjacent to the Caspian Sea and on the Greater Sunda Islands of Sumatra, Java, and Bali. Except for Sumatra, where tigers now live in scattered, critically endangered subpopulations, they have disappeared from these outer islands and the Caspian shores. All the fragmented tiger subpopulations will continue to decline unless remedial measures are directed at each. Hostile conditions prevail in the areas between forest fragments; forest fragmentation and deterioration continues; prey populations have been decimated; and tigers in whole forest blocks are being poached. Many of the potential tiger subpopulations identified in 1997 are so small that a single threatening event—pathogens, poachers, floods, fires, or droughts—could rapidly decimate these remnant populations. The primary value of TCU 1.0 was that governments and conservationists now had a collective image of where priority conservation actions could be directed at individual subpopulations to ward off their individual extinctions, rather than directed at the species as a whole. This has allowed tiger conservationists to shift their focus from the activity of saving the tiger, which had been the prevailing species-orientated conservation paradigm, to results-focused actions of supporting sustainable populations of wild tigers in their different habitats by protecting, recovering, and linking these together wherever possible.

This new vision for tiger conservation went far beyond saving tigers in a few well-known reserves and national parks to conserving tigers in large, tiger-friendly landscapes. This shift in spatial scale was important because all reserves are often too small to contain viable populations of large carnivores (Woodroffe and Ginsberg 1998) and reserves are, or will eventually become, isolated. Thus, the species-based approach was essentially a process of honoring the well-known places where tigers lived and where most will eventually die out. A generation of conservation science has taught us to recognize this as a hospice strategy. In contrast, a landscape-scale approach to tiger conservation, born in part from STF investments based on the TCU framework, aligned conservation efforts with science, rather than continuing to funnel disproportionate funding to small parks whether they were viable or not but were in the public eye and championed by individuals and groups. We care passionately about tigers living in these areas but in the end our science predicts that most will not survive.

TCU 1.0 established an ecological basis for tiger conservation investments. TCU 1.0 affirmed that effective conservation must be based on sound science. The working hypothesis is that for tigers to survive over the long term, tigers and their prey must be managed at a landscape scale; only this approach will ensure the persistence of tigers. Effective tiger landscapes must include core areas (national parks and reserves) of protection, buffer zones where tigers are fully protected, dispersal corridors to connect core areas, restoration of degraded lands, and initiatives through which the conservation of tigers directly or indirectly meets the need of local people.

These landscapes where tiger subpopulations lived or could live were deemed Tiger Conservation Units, TCUs, in TCU 1.0 and the TCUs became the fundamental level for conservation investment to create conditions where these subpopulations can remain viable or can be made viable (see Chapter 8 for a summary of investments in tiger conservation by TCU). TCUs were prioritized by regions in recognition of the differences in tiger density in various vegetation types and biomes. The amount of tiger prey available living in various vegetation types and biomes across the tiger's broad geographical range varies from about 1 to 100 individual prey animals per km^2. Monitoring has demonstrated that tiger densities vary by a factor of 30, from less than 0.5 per 100km^2 (tigers one year of age and older) in the temperate forests of the Russian Far East and some tropical rainforests to more than 15 per 100km² in the flood plain grasslands and riverine forests of Nepal and India. The area it takes to support viable tiger subpopulations in different vegetation types varies accordingly. A critical threat to tiger subpopulations, which has been documented since the publication of TCU 1.0, is that tiger prey populations are depressed both within and outside protected areas through most of their remaining range (papers in Seidensticker et al. 1999).

TCU 1.0 recognized that you cannot manage what you cannot measure. Reactive management is inevitable when ecological knowledge is insufficient to allow reliable science-based predictions. Save The Tiger Fund, with principal partners including the Wildlife Conservation Society, World Wildlife Fund, Wildlife Institute of India, Flora and Fauna International, Sumatran Tiger Conservation Project, Zoological Society of London, University of Florida, University of Minnesota, and U.S. Fish and Wildlife Service, has supported a decade of work to overcome our inadequate knowledge of tiger distribution, dispersal behavior, and ecological needs that were outlined in TCU 1.0. It is now time to bring this updated and new information together with more recent land cover and human footprint data (Sanderson et al. 2002). At conferences and workshops sponsored by Save The Tiger Fund, including the Tigers 2000 symposium at the Zoological Society of London in 1997 (Seidensticker et al. 1999), the 1998 Year of the Tiger Conference in Dallas (Tilson et al. 2000), and the Assessing our Success workshop held at the Wildlife Conservation Society in New York in 1999 (Ginsberg 2001), the ineffectiveness of individual conservation practitioners, organizations, alliances, and networks working without a common vision and language was recognized as a primary threat to the tiger's future. Consequently, when the Save The Tiger Fund suggested to WCS and WWF that we should update and refocus tiger conservation actions based on the new information that has become available over the last decade, we immediately sought key additional partners to join in this effort. Financial and technical support was readily offered by Save The Tiger Fund, World Wildlife Fund–U.S., Wildlife Conservation Society, United Nations Foundation, U.S. Fish and Wildlife Service, Critical Ecosystem Partnership Fund, Zoological Society of London, the Smithsonian Institution, and from our many contributors listed in the Acknowledgements. The effort has spanned 18 months. The result is the best image of where tiger conservation is today and where and how we should continue or refocus our investments.

Wild tiger conservation is an umbrella for the protection of all biodiversity in the Asian forests where they live and for the ecological services these forests provide. Tiger areas conserve watersheds, protect flood plains, and rice bowls and in many ways contribute to human development indirectly as being the justifications for protected areas that provide many ecological subsidies from nature conservation. It is heartening for tiger conservationists that we have gained ground for some tiger subpopulations, but we have lost ground elsewhere. We know that we have to do better than we have done so far if wild tigers are to survive. The challenge of saving the tiger is at the heart of conservation. A world without tigers is a world without hope . . . like a clear night sky without stars. A world without tigers would be a terrible loss, symbolizing a morbid disregard for our natural heritage, natural places, and the essential goods and services these areas provide for all of us.

— *John Seidensticker, Eric Dinerstein, Joshua R. Ginsberg*

1.2 The Need for a Tiger Framework Document (TCL 2.0)

TCU 1.0 broke new ground as a conservation tool for prioritizing investments for wide-ranging species. Specifically, it provided strategic guidance to conserving tigers by moving beyond a focus on individual protected areas and instead promoted landscape-scale conservation across a variety of land use types. TCU 1.0 also united two fundamental goals of biodiversity conservation, the representation of habitats and the conservation of the ecological adaptations associated with distinct species assemblages. For the first time, prioritization was based less on which population had the highest estimated number of tigers, but rather, within a given habitat type or biome, which block or blocks of habitat, dubbed Tiger Conservation Units (TCUs), offered a tiger population the best chance of long-term persistence. Persistence was estimated by three main variables: the configuration of the landscape, poaching pressure on tigers and their prey, and general trends in tiger numbers.

The success of TCU 1.0 can be evaluated in several ways. First, several major donors interested in tiger conservation adopted the framework to guide investments towards the most promising areas for tiger conservation within each biome and bioregion. Second, it prompted researchers to investigate areas identified by TCU 1.0 as poorly surveyed to fill in gaps in knowledge. Third, it also did the reverse, stimulating some biologists to revisit areas where they questioned the validity of some of the rankings of TCUs. These last two steps provided much needed checks on the original analysis, which was conducted over a three-month period. Finally, the representation approach to tiger conservation was applied to other wide-ranging species such as jaguar, bears, elephants, and crocodiles (Sanderson et al. 2002).

Nearly a decade has passed since the publication of TCU 1.0 and an even longer period in terms of the underlying data used to conduct that analysis. The purpose of this study (hereafter TCL 2.0) is to:

1) update the still widely-used TCU 1.0 by incorporating progress made in conservation theory, and new results from in-depth field studies and surveys on tigers, their prey and habitats across the tiger’s range;

2) reassess, revise, and redefine what we are now calling the Tiger Conservation Land-

scapes (TCLs) based on changes in land cover and habitat availability over the last decade, and refine the TCU boundaries using new GIS analyses;

3) employ global datasets on threats and human use, and incorporate analyses that place tiger conservation in the context of information databases such as the 2004 World Directory of Protected Areas or the global distribution of World Heritage Sites; incorporate information on other flagship species such as rhinos, elephants and orangutans; and examine priorities in light of the tiger project investments database developed and maintained by the Zoological Society, London;

4) improve the transparency and rigor in identifying and ranking TCLs through computer-based methods that will facilitate easy updating and allow us to measure progress towards conservation goals; and

5) overlay updated TCL priorities in conjunction with other regional conservation initiatives, such as priority areas for elephants, and world heritage sites, to identify synergies and gaps in biodiversity conservation investments.

The outcomes will provide a revised roadmap for tiger conservation through recommendations for the next 10 years, and identify areas of collaboration for regional conservation action. It will also allow us to better track investments in biodiversity conservation aimed directly at tiger conservation and biodiversity and resource management in general. To create a truly living document, we hope to take the data collected for this exercise, and our analyses, and develop an online Tiger Conservation Database—an interactive science tool that provides data and analysis created during our proposed project using interactive map server technology and online publishing. Hence we use the terminology "TCL 2.0" to indicate that the current exercise will be updated more regularly, with smaller, incremental improvements over time as is done with small upgrades of software.

There is a widely held belief that while some tiger populations in selected TCLs have increased over the past decade, the total tiger population is still in decline. We need to reverse the downward trajectory as rapidly as possible in key areas identified by this analysis. On the plus side, we can point to some clear successes on how to move forward. STF and other donor investments led to the creation of flagship landscape-scale conservation projects, such as those underway in the Terai-Arc Landscape in Nepal/India, and in the Russian Far East. Research conducted by STF grant recipients have provided us with better estimates of tiger and prey densities in key parts of TCLs that enable us to sharpen our predictions about how productive different habitat types can be for tigers. Expanded information on where tigers do and do not exist was generously provided by numerous field workers and greatly aided our analyses. However, improved capture of information on survey efforts, and particularly on negative results (places where no tigers were found), would help us hone these analyses further.

The vastly improved data on tigers that we did obtain, and on conservation efforts, allowed us, in this analysis, to develop a classification of TCLs based on the tiger's ecological requirements that is a precursor to, but separate from, their prioritization. We first classified tiger conservation landscapes into distinct classes (Class I, Class II, Class III, and Class IV) with each of these classes related to the probability of reaching our goals for tiger conservation over the next decade. Subsequently, we then prioritized individual TCLs by bioregion and biome, maintaining our goal of representation of 'tigerness' across their range.

Hence, the guiding principles of the TCL 2.0 analysis are:

1) ensuring that the concept of "tigerness" (representation of the suite of adaptations by tigers to different habitats) stays central to prioritization of conservation investments across its range;

2) securing the breeding populations within TCLs because they serve as the source populations for the recovery of tigers and their prey across the TCL landscape;

3) increasing the potential for expanding breeding populations across TCLs through appropriate land use designations and incentives; and

4) identifying and strengthening zones of poor connectivity between and among TCLs to create large functioning conservation landscapes for tigers and the species that fall under their umbrella effect.

Taken together, these principles, or building blocks, enable us to begin thinking about the concept of meta-TCLs, giant landscapes of reconnected habitat spanning vast areas of the tigers' range. Over the long term, we envision promoting the idea of 100,000 tigers by the year 2100 across TCLs. The steps for the recovery of tiger and prey populations have long been known: reduce poaching, protect breeding habitat, reduce competition with domestic livestock, and provide the incentives for rural people to coexist with wildlife in tiger-friendly landscapes. The field techniques and technologies are available to achieve this visionary goal if the political will is matching. TCL 2.0 is a footbridge to that visionary goal.

— Eric Dinerstein, John Seidendsticker, Joshua R. Ginsberg

Chapter 2 Methods Used to Assemble Tiger Data Layers for TCL 2.0

2.1 Introduction

Data on the status and distribution of tigers that are current and systematically collected are essential to plan and monitor the effectiveness of tiger conservation efforts. In this context, spatially explicit data were used to drive the delineation and prioritization of tiger conservation landscapes (TCLs) across their entire range. This represents a major advance from the original 1997 Framework Document (TCU 1.0), which delineated tiger habitat using a method based largely on a geographic information system analysis of forest cover maps, supplemented only when possible by information collected from regional and local experts as well as published and unpublished results. To map tiger habitat in 2005, we rely much more heavily on tiger distribution data. This advance was possible due to knowledge gained on the status and distribution of tigers in the wild since the publication of the 1997 Framework Document. This reflects the concerted effort of the Save The Tiger Fund, the U.S. Fish and Wildlife Service, 21st Century Tiger, and the role of international and national non-governmental organizations (e.g. the Wildlife Conservation Society, World Wildlife Fund, Wildlife Institute of India, Flora and Fauna International, Sumatran Tiger Conservation Project, Zoological Society of London, University of Florida, and the University of Minnesota), and national governments to work to conserve tigers in their native habitats, and to ensure that data collected in these efforts is widely available. Although both tigers, and tiger conservationists, continue to face many challenges, we now have a base of information on which to build better and more effective conservation efforts.

In many places across the tiger range, positive changes have occurred: conservation measures have been implemented, and people and governments are committing themselves to tiger conservation both through activities on the ground, policy change, and by raising and supplying necessary funds to support conservation efforts. However, many questions remain unanswered such as the extent of threats, where and what is being done to conserve tigers, the effectiveness of tiger conservation efforts, and the status and changing status of tiger populations across their range.

To try to answer these questions, we decided that our first step must be to systematically build a comprehensive database of tiger data from governments, researchers, experts, and conservationists working on the ground throughout the tigers range. To construct this database, we designed two questionnaires to extract tiger information at two distinct scales: the scale of the TCUs as defined in the 1997 Framework Document, and the scale of point locations of tigers. Responses to these questionnaires were used to assist in delineating and prioritizing TCLs for TCL 2.0 as described in subsequent chapters. They also serve as a measure for examining how effective past tiger conservation efforts have been, while creating a baseline against which future tiger conservation efforts can be compared.

2.2 Questionnaire Survey Methodology

In Spring 2004 two types of questionnaires, prefaced by a cover letter and accompanied by maps of the region, were e-mailed to 273 individuals believed to be working in or around TCUs that were delineated in 1997. Descriptive and quantitative questions were aimed to document, through expert and on the ground knowledge, the status of tigers and tiger conservation within TCUs. Their answers were used to help determine the new delineation and prioritization for TCLs in 2005.

2.2.1 Mailing List

We created an expansive list, both geographically as well as being representative of a wide range of expertise with regards to tiger conservation. Names and e-mail addresses were initially collected from WCS, WWF, and STF contacts that included all known researchers or people with tiger knowledge from NGO's, governments, academia, and individuals working in tiger range. Contacts were also taken from published and unpublished reports, as well as 'gray literature.' Upon receiving the questionnaire packet, respondents were asked to inform the sender of other individuals to whom the questionnaires could be sent as well as to indicate if they had received the packet in error.

2.2.2 Questionnaire Design

Two questionnaires were designed and implemented. The first questionnaire, labeled "TCU Questionnaire," focused on collecting information on existing TCUs (TCU 1.0), including status of tigers, evidence of breeding, a threats assessment, determining what conservation measures were present and ranking their effectiveness, and information about the contributing researcher(s). If a respondent received the questionnaire but did not have information for a particular TCU, they were asked to indicate on the map provided (by circling the appropriate area) where their information pertained. An example of the TCU Questionnaire is provided in Appendix 1.

Respondents were asked to assess the status of tiger populations through a series of questions about attempts made to scientifically document tigers. Questions asked whether tigers had been documented and if so through what methods; we also asked about knowledge of tigers breeding; if there was a scientifically documented population estimate and to describe methods used to calculate that estimate.

For the threats assessment section, we used a modified form of The Five-S Framework for Site Conservation to calculate a vulnerability score for the TCU in question (Nature Conservancy 2000; Coppolillo et al. 2003). In this section, we provided a list of potential threats and asked the respondent to rank the severity (S) (how much is the threat reducing tiger populations?); urgency (U) (when will the threat occur, if it is not occurring now?); recovery time (R) (how long will it take for tigers to recover from the threat if it were to be removed?); the percentage of area (Pa) of TCU affected by the threat; and the probability (Po) of the threat occurring, assuming it is not occurring already. This methodology allowed us to distinguish and include both currently occurring and prospective threats in the analysis. We supplied guidelines to indicate the parameters for each variable, which could be ranked from 0 to 3 (Appendix 1). We used the following equation to determine a threat score (or vulnerability index) for each threat:

$$\sum\{(U + R) \times S \times Pa \times Po\}$$

Scores were calculated and summed for each threat to obtain an overall threat score for each TCU or other area. We also examined the total value for each threat across the tiger's range (Table 2.1).

Conservation measures were assessed by first providing a comprehensive list of potential measures, such as education, patrolling, monitoring, etc, and then asking respondents first if the conservation measure was present and if so, to rank the effectiveness of that measure on a scale of 1 to 5; 1 signifying that it is not effective at all and 5 indicating the conservation measure is fully effective. If the conservation measure was not effective, but the respondent indicated that it would be in the near future, a score of 0.5 was used. To summarize conservation effectiveness for each TCU, we summed the effectiveness responses for all conservation measures (Table 2.2). These summed scored would later be used in the TCL prioritization process (see Chapter 6).

For purposes of prioritization, it was necessary to further summarize the TCU questionnaire data into measures of population status, breeding, threats, and conservation measures for each TCU. In general if we received multiple responses for the same TCU we averaged the values, except for where results were reported by response rather than by TCU.

In many cases the questionnaires were not fully completed and only some information was provided. Fields that were left blank were documented as "no data"; if the respondent answered "unknown" or "don't know" these responses were also documented. In general if certain fields in the Threats Assessment were left blank, scores could not be determined. However, for certain TCUs where Severity (S), Proportion of Area (Pa), or Probability of Occurrence (Po) were filled in as zero, the threat score equaled zero due to the nature of the equation used above. If more than 10 conservation measures were left blank (out of 22 given measures), and the respondent did not indicate that the conservation measure was not present nor would it be in the near future, an accurate conservation effectiveness score could not be calculated for that measure and it was flagged as an area in need of data.

The second questionnaire, the "Tiger Conservation Database (TCD) Survey" was sent in conjunction with the TCU Questionnaire and focused on tiger-point locations, search effort, evidence of tiger presence or absence and tiger breeding, as well as observation and location methods. A point location (referenced by latitude and longitude coordinates) was defined as the collection of all observations made to locate a tiger within a three-month period and within a 20 km radius of the location center, whether or not a tiger was sighted. Tigers do not need to have been sighted to record an observation, only that a tiger or tiger sign was searched for using scientific methods (Sanderson et al. 2002). Point data from the TCD surveys, complemented by additional data points gleaned from the literature (below) were used in TCL delineation.

2.2.3 Additional Data Points

Besides data gathered from the TCD survey, additional tiger-point locations were added from other sources such as reports to Save the Tiger Fund (STF) and the U.S. Fish and Wildlife Service (USFWS), which have funded numerous studies on tigers, their habitat, prey, and ecology. We included information from 217 STF final reports (1995–2004), 9 additional USFWS reports (1998–2001) and 27 reports published by WWF, WCS, Cat Action Treasury, scientific papers, published reports, and data from the Project Tiger Web site: http://projecttiger.nic.in/map.htm (Appendix 3).

2.2.4 Data Collected from Two Open Revision Phases

On June 28, 2005 an e-mail was sent to the revised tiger distribution list (n = 162) with a detailed letter requesting their review of the first draft of the newly defined TCLs, as well as maps of the tiger data used to produce the delineation. The letter contained a link to a specially created web page (http://www.wcs.org/tigermaps) where the first draft of maps could be downloaded, along with a PowerPoint file with explicit instructions and information as to how the maps were created, how to review them, and how to submit comments. Participants were given three weeks to respond and were sent weekly e-mail reminders. Prior to this e-mail, a letter went out on June 10 giving notice that a revision period would be coming up so that participants would be prepared in advance. Again, on December 2, 2005, the participants were solicited to review and comment on the draft classification and prioritization of the previously delineated TCLs. The same methods were used to solicit a review of the maps: a PowerPoint file with all relevant information for review and submitting comments was made available for download. As in the first round, an e-mail went out on November 23rd indicating that the second revision phase would be occurring on December 1. We hoped that these additional e-mails would give people the appropriate forewarning in order to get as much feedback as possible.

2.3 Summary Questionnaire Results

2.3.1 TCU Questionnaires

Three mailings to an initial 274 participants (May 25, June 9, and June 29, 2004) reduced the list of potential respondents to 162 individuals due to insufficient e-mail addresses as well as eliminating multiple entries from organizations where one individual responded for the group. Out of 162 individuals, 58% responded (n = 94). This included individuals who did not submit data but responded in some manner. Twenty-seven (17%) individuals responded with tiger-point data, and 77 individuals (48%) submitted data in the form of one or more questionnaires (respondents were asked to complete a separate questionnaire per TCU) resulting in 102 total questionnaires. Seventy-nine percent (n = 81) of the questionnaires referred to 59 of the existing 159 TCUs, and for 15 of those TCUs we received more than 1 questionnaire. Twenty individuals responded to areas outside of TCUs, 12 of whom provided location maps for their comments and 8 provided no location. Of the 59 TCUs for which we received data, 22 were the original Level 1 TCUs, 5 were Level 2, 26 were Level 3, and 6 were Level 4.

2.3.1.1 Status of Tigers

Ninety-seven percent of TCU questionnaire respondents reported an attempt to scientifically document tigers in the TCU or other area described from 1995 to 2004; of that group, 90% indicated they had successfully documented tigers in the TCU or area. Methods included camera traps, track and sign, and pugmark surveys (Figure 2.1). Besides scientific documentation, 65% reported other methods of documenting tiger presence such as unpublished reports (n = 15), local reports and anecdotal information (n = 9), interview surveys (n = 8), tiger depredation of livestock (n = 7), "problem" tigers (n = 6), sightings by local people (n = 5), tiger poaching (n = 3), and captured tigers (n = 2). Asked whether tigers had been scientifically documented since January 1, 2003, the majority (56%) responded "yes," 42% responded "no" and only one individual was unsure. Again, of those who responded "yes," camera traps, track and sign, and pugmarks were the methods most often used to document tiger presence (54%, 32%, and 22% respectively).

More than half of the respondents (53%) had found evidence of tigers breeding, which was defined to be presence of cubs, a pregnant female, a den, or mating. Twenty-nine percent had not found any evidence, and 18% did not know whether tigers were breeding or not. Of those who had found evidence, 91% reported that cubs had been observed. Less than 13% reported finding a den, observing tigers mating, and observing a pregnant tiger. Other types of evidence that tigers were breeding were tracks of females with cubs (n = 11), local reports (n = 6), confiscated cubs (n = 4), a "problem" tiger was captured with her cubs (n = 1), and, in one instance, cub pelts were confiscated (n = 1).

The majority of respondents (61%) reported a scientific population estimate for their TCU or area. Twenty-nine percent indicated population estimates greater than 100 tigers within a TCU, followed by 27% indicating 10 to 20 tigers. Camera trapping was the primary method of choice (73%), followed by track and sign (14%), and pugmark surveys (1%).

2.3.1.2 Threats Assessment

Lack of enforcement, hunting of tiger prey, low tiger population size, and incidental hunting of tigers posed the highest threats to the tiger's survival. Disease, competition from other carnivores, and civil unrest were perceived as little to no threat to tigers (Table 2.1).

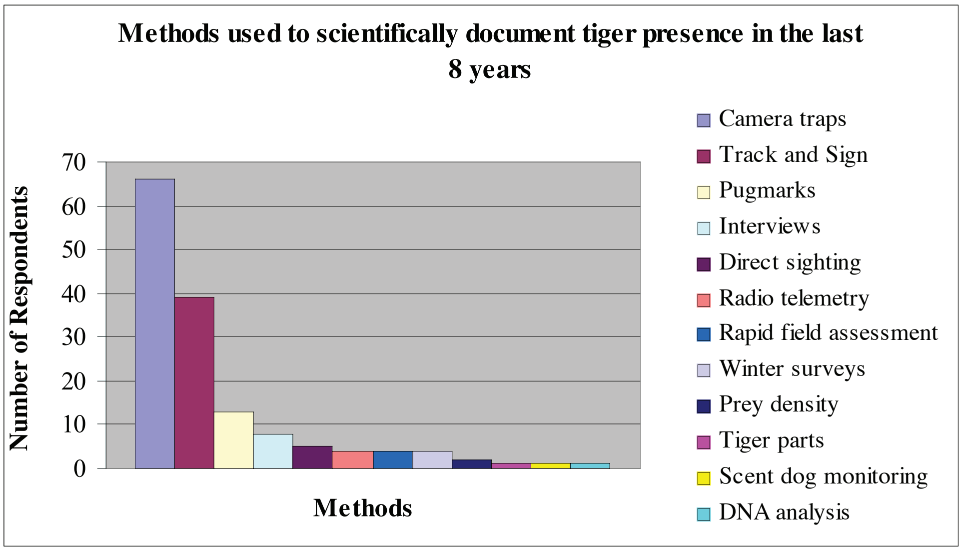

Figure 2.1 Methods used by respondents to scientifically document tiger presence.

Of the existing TCUs and demarcated areas, China received the highest threat score (776), followed by Myanmar, TCU IC013 with a score of 543. Thailand SA001, Nepal IS006, and India IS003 received the lowest threat scores, indicating that threats did exist but were thought to present a minimal impact to tigers in these areas (Appendix 2). Twelve TCUs had insufficient data to calculate vulnerability scores; these TCUs were identified as areas in need of more data (see Chapter 6 to learn how these TCUs were incorporated in the prioritization).

2.3.1.3 Conservation of Tigers

Conservation effectiveness scores were calculated for 22 identified conservation measures (Table 2.2). Education of local people and school children, training of protected area staff, and anti-poaching patrols received the highest scores for being the most effective conservation measures (169.5, 163.3, 159.2, and 153.0 respectively). Captive breeding and reintroduction were seen as being the least effective conservation measure. The TCUs with the top five highest effectiveness scores were in Nepal, Malaysia, Bhutan, and India. The 13 lowest scores per TCU fell within TCUs in Malaysia, as respondents indicated that conservation measures were not yet occurring in these places.

Respondents were asked to name Protected Areas (PAs) that occurred on some part of the TCU. Most of the respondents (n = 95) listed one or more PA. IC101 (Thailand), IS055 (India), and the Russian Far East were listed as containing or overlapping with as many as thirteen PAs. Ninety-eight percent (n = 100) of respondents listed at least one government agency or department responsible for tiger conservation within the TCU. Besides tigers, 98% indicated that there were other species of conservation interest within the particular TCU. Overall, 234 separate species were listed, among the most frequent, and in descending order, were the Asian elephant (*Elephas maximus*), Gaur (*Bos gaurus*), Leopard (*Panthera pardus*), Agile gibbon (*Hylobates agilis*), and Siamang (*Hylobates* *syndactylus*). Most respondents (88%, n = 90) had worked on tiger conservation in the TCU during the last 8 years; 5 had not, and 7 did not provide any data. Seventy-five percent listed 1 to a maximum of 16 individuals who had worked within that TCU on tiger conservation.

2.3.1.4 Additional Data Collected from the Delineation Open Revision

From the June 28, 2005 open revision, 36 individuals from the field responded with comments and additional data. During this phase, new descriptive data were collected and incorporated for 2 new areas in India including threat and conservation effectiveness scores. The majority of data collected in this revision phase, however, came in the form of tiger point locations (see section 2.3.2).

Threat	Vulnerability Score
Lack of enforcement	1942.8
Hunting of tiger prey	1936.1
Low tiger population size	1909.1
Incidental hunting of tigers	1544.8
Lack of connectivity	1510.0
Habitat degradation	1499.3
Export of tiger parts to other areas	1461.9
Habitat destruction	1385.7
Directed hunting of tigers	1325.2
Resource exploitation	1229.0
Local trade in tiger parts	1049.7
Lack of legal protection	585.7
Civil unrest	188.7
Competition from other carnivores	176.4
Disease	21.7

Table 2.1 Threats Assessment: A high vulnerability score indicates that the threat is severe (i.e. it is reducing tiger populations), it is urgent, and it is affecting a large number of TCLs across the entire range.

2.3.1.5 What we know now about "priority survey" TCUs from 1997

From the 1997 Framework Document, 20 TCUs were identified as "priority TCUs for immediate surveys." We received 12 questionnaires pertaining to 8 of these identified TCUs (Appendix 1). Data provided for these 8 TCUs showed that there had been a successful documentation of tigers during the last 8 years except for in TCU IS059 (India). Since January 2003, tigers had been scientifically documented in all of the 8 TCUs mentioned above except in IS059 or IS016 (both in India). Tigers were documented with camera traps (n = 4), pugmarks (n = 2), and one first-hand sighting. Evidence of tiger breeding was documented for all eight TCUs, and all had observed cubs except for TCU IC001 (Myanmar), where anecdotal reports indicated tigers had been seen with cubs in the TCU over the past eight years. Four TCUs had tiger population estimates greater than 100 tigers: IS016, IS025, IS031, and IS059 (all of which are in India).

Conservation Measures	Score
Education of local people	169.5
Education of school children	163.5
Training of protected area staff	159.2
Anti-poaching patrols	153.0
Monitoring of tigers in the field	151.5
Enforcement of protected area policies	149.0
Provisioning or monetary support to protected area staff	141.0
Enforcement of existing laws regarding tigers	134.5
Local publicity about tigers	132.5
Monitoring of prey populations	129.0
Anti-trafficking enforcement	104.0
Ecotourism ventures	104.0
Compensation programs	99.0
New laws/policies for tigers	92.5
Conflict management/mitigation	90.0
Monitoring of trade in tiger parts	79.5
New/upgraded protected area	78.0
Translocation of local people out of protected area	75.5
Habitat restoration	67.5
Habitat enhancement	57.5
Captive breeding facility	23.5
Reintroduction of tigers	8.0

Table 2.2 Effectiveness of Conservation Measures: High scores indicate that that specific conservation measure is considered to be effective. Scores were determined using a 5 point scale (1 being not effective, 5 being fully effective).

2.3.2 Results from TCD Questionnaires

As a result of the 3 mailings in the summer of 2004 requesting the submission of tiger data, and before the open revision process began in June 2005, a total of 1553 tiger-point locations were collected from all 13 countries (Figure 2.2). (See Chapter Four for a map depicting tiger point locations.) This point database was complemented by a database on surveyed areas, or "polygons," which before the review had 391 records referring to 285 unique areas. On June 28, 2005, we sent out the first draft version of the delineation to the tiger community (n = 162) for their comments and review. Thirty-one individuals responded via e-mail with elaborate comments and additional data and six tiger biologists from Russia, India, Malaysia, Thailand, and Cambodia reviewed the maps in person in the WCS New York office, resulting in a response rate of 22% and acquiring 1,841 additional points from the review period, resulting in 3,394 tiger-point locations.
Of these points, 653 were duplicates, resulting in a total of 2,741 usable point locations. Following the review, the polygon database was also updated to include survey results of 19 new places.

Of the points, 91% (n = 2517) indicated that some evidence of tiger presence had been determined, 8% (n = 222) had not found any evidence, and only 1% of the points, had no data regarding evidence or no evidence of tiger presence (Figure 2.2). Only 8% (n = 208) of the total points resulted in evidence of tiger breeding, 45% (n = 1,245) had no evidence, and 447% (n = 1,288) had no data (Figure 2.3)

Sixteen percent (n = 432) of point locations did not include data pertaining to observation or location methods, thus the following percentages are out of 2,309 points. Tiger tracks or pug marks (65%); photographs, i.e. camera traps (42%); radio telemetry (21%); and scat (19%) were the most frequently recorded methods for making tiger observations, and using a map and compass (17%), GIS (12%); and GPS (11%) were the most frequently used methods to determine tiger location. Utilization of differential GPS and satellite collars were not reported as methods used.

2.4 Discussion of Questionnaire Analysis and Results

Eighty percent of the respondents were able to contribute data to 59 (36%) of the existing 159 TCUs delineated back in 1997. However, out of the 102 questionnaires received, the majority (n = 36) came from Level 1 TCUs; 7 pertained to Level 2, 27 were Level 3, and 9 were Level 4. We received more responses from Level 1 TCUs than any other level, indicating that recommendations from the original 1997 Framework Document may have had an impact on priorities for tiger conservation activities, thus making data more readily available from these TCUs.

Overall, the responses to the questionnaires for both the TCU and the TCD forms reveal significant effort in working to document the status of tigers in the wild, and the majority had attempted and succeeded in scientifically documenting tigers during the last eight years using scientific methods, mainly pug marks and camera traps (often in conjunction with each other). This was the same situation regarding scientific documentation of tiger population estimates: 73% obtained estimates based on camera trap data. A positive response was relatively lower when asked if tigers had been documented since January 1, 2003; only 53% reported that tigers had been documented in the previous year. At the time of receiving this questionnaire, it had been 16 months since January 1, 2003, perhaps too short of a time period for some to be able to conduct surveys; however reasons for why this number is low are only speculation. The low level of "negative" data—places surveyed where tigers were not found—may indicate either a bias to surveying areas where tigers are likely to occur, or more likely, an under-reporting of negative results. A clearer and more statistically robust definition of "absence" would be useful and might provoke a better response (see that given by results in Carbone et al. 2001 or as discussed in Karanth & Nichols 2002).

Lack of enforcement received the highest cumulative threat score (1942.8) yet lack of legal protection appeared to have the fourth lowest score (585.7). Conceptually, and structurally, the best policies can be instituted and legal protections put in place, but without people on the ground to actively and effectively protect tigers from direct hunting and

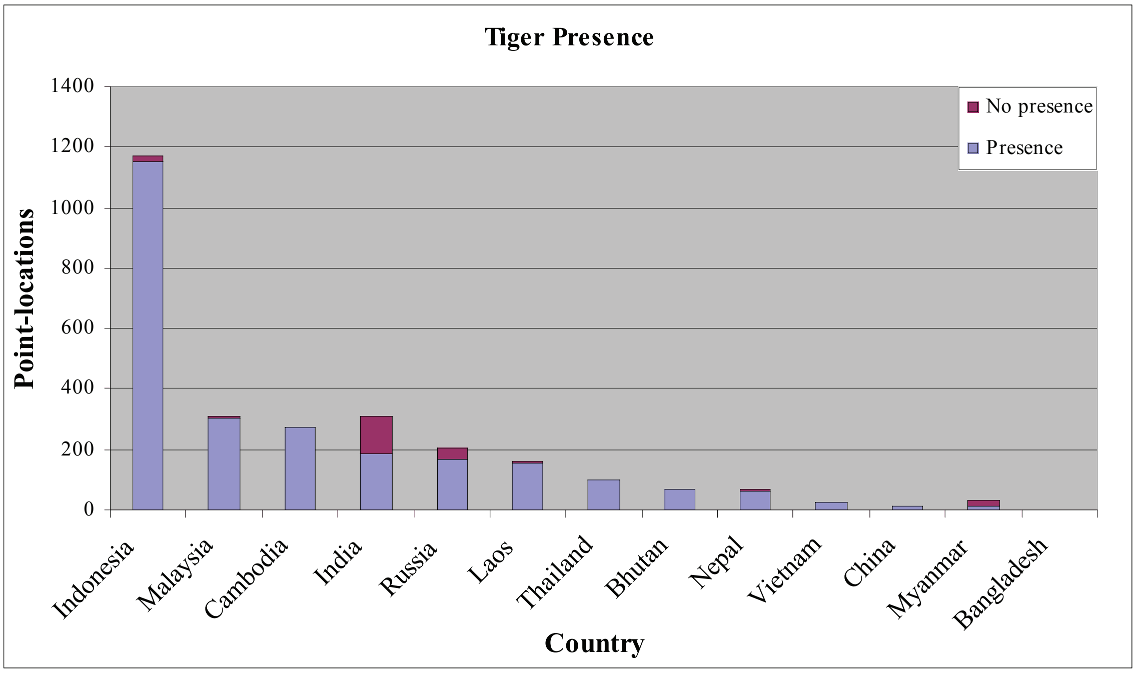

Figure 2.2 Survey Results: Total tiger-point locations and evidence of tiger presence, by country (total point locations = 2,741). Tiger point-locations (each point-location is the collection of all observations made to locate a tiger within a 3 month period and within a 20 km radius of the location center, whether or not a tiger was sighted) collected from the TCD survey and the revision process, by country.

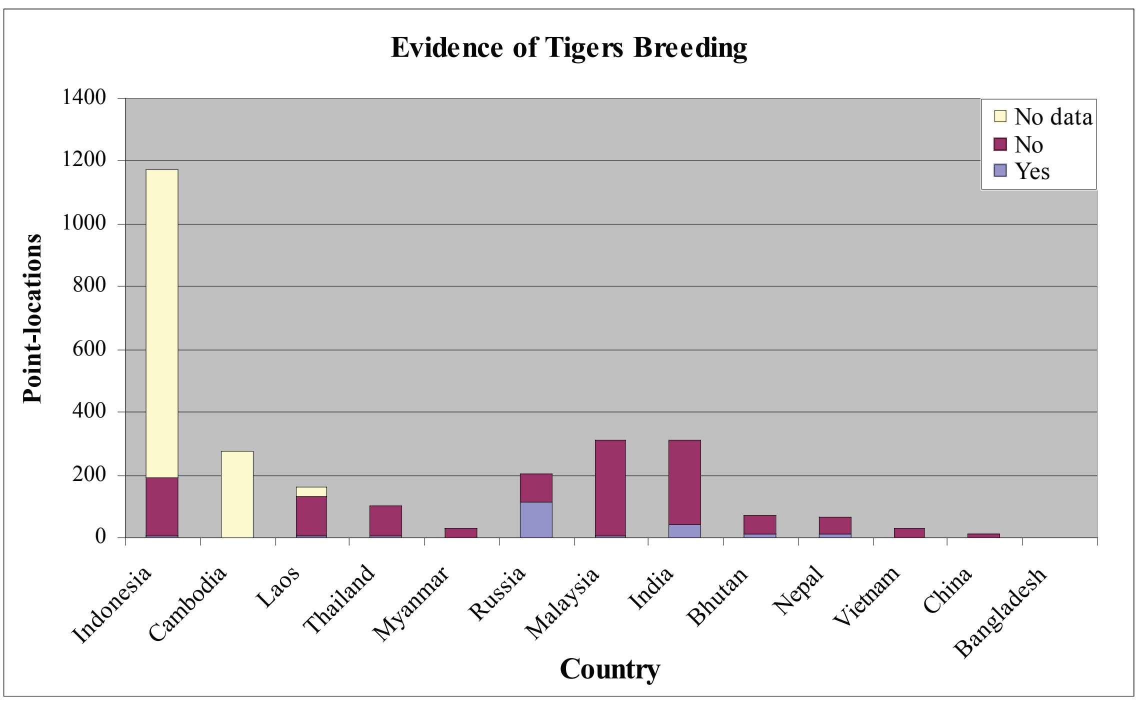

Figure 2.3 Evidence of tiger breeding documented by country (total point locations = 2,741).

hunting of tiger prey, lack of enforcement can have a cascading effect and render legal policies ineffective. Increasing enforcement is not the panacea for tiger conservation, but identifying where and why enforcement is not occurring—whether due to lack of capacity building, funding, incentive, or effective punishments—and to determine in places where there is effective enforcement, and how this is impacting tiger populations, is a worthy and needed endeavor.

The most effective conservation measures (those that had the four highest scores) were all related to education and training: education of local people and school children, training of protected area staff, and anti-poaching patrols. Involving communities and individuals of all ages, and building local and national capacity were viewed as effective conservation measures, and should be an integral component of tiger conservation. Over 70% of respondents indicated that some type of education or training was occurring in their TCU.

Questionnaire respondents were asked to list other species of importance besides the tiger within the TCU on which they were reporting. Two hundred and thirty-four other species were listed and included mammals, birds, fish, reptiles, herps, amphibians, and plant species. The top 8 consecutively-listed species were the asian elephant, gaur, asiatic black bear, leopard, agile gibbon, siamang, clouded leopard, and dhole. These species were listed for all levels of TCUs indicating that tigers are not the only conservation priority within these areas, and that a vast array of wildlife including many endangered species, live within these TCUs.

We were able to capture data pertaining to tiger distribution (from TCD questionnaires) and descriptive data pertaining to general tiger conservation efforts resulting in information for threats and conservation measures (through the TCU questionnaires). We did not capture significant or adequate data regarding the status of tiger prey, as only 2 questions on the TCU questionnaire dealt limitedly with this topic. The vulnerability index calculated for hunting of tiger prey placed this threat as the second highest and monitoring of tiger prey placed in the middle as an effective conservation measure. Long-term studies regarding the status of tiger prey do exist (Karanth et al. 2004; Miquelle et al. 1996; 1999; and O'Brien et al. 2003), however there is both the need to compile tiger prey data that already exist as well as conduct far more long-term research to determine prey estimates and status across the tigers range. The lack of availability of these data poses a constraint in assessing the state of tigers in the wild and reaffirms that efforts in the future need to involve determining the status of prey populations.

2.4.1 Limitations, Constraints, and Recommendations

The most important data collected from the questionnaires pertained to tiger presence, tiger breeding, and scores from the threats assessment and effectiveness of conservation measures. These variables helped delineate and determine classification and prioritization for TCLs in 2005. However, we believe that we did not capture all available data. Data sharing, especially on a large scale, comes with many issues. Researchers and scientists, either individuals or those working for organizations and governments, have put tremendous effort and resources into collecting their own data—data that will aid in tiger conservation efforts, but also data that they hope to publish, and to which they are connected and have ownership. Pooling such data into a large, collective process goes against what many scientists have spent years doing. We tried to counteract any feelings of mistrust or fear from the beginning by sharing our clear objectives, our methods along the way, how data would be processed and contributors acknowledged, by having open revisions, as well as having one point of contact for participants to communicate with and answer questions at any time. We also asked for data to be submitted at a courser scale so as not to compete with any local analysis objectives which they might have.

Besides not wanting to share data, we believe that other data gaps exist for other reasons. Some data are just scarce (i.e. prey data, specific data on the trade of tiger parts, ecological tiger data from inaccessible areas due to political situations, etc); sometimes data collected incidentally are not recorded in a systematic manner, for instance data on prey occurrence in camera trapping exercises. Another reason may be that we were unable to capture a wide enough distribution with the questionnaires through our contacts list; also, we believe that data confirming tiger absence may not have been as readily supplied as data showing tiger presence. Out of 3,394 point locations, 88% (n = 2,973) had confirmed tiger presence. We stressed that a tiger point location was defined as "search effort" regardless of whether a tiger was found or not, and that survey efforts that resulted in not finding tigers is just as important, if not more so, than efforts that determined tiger presence.

Besides the scarcity of data, there is the issue of questionnaire data quality. Keeping questions open ended, asking about methods used and how estimates or locations were determined can help to some extent determine the credibility or weight of responses; however, remaining true to the inclusive process we defined from the beginning, all comprehensible data were entered in the database and used for the classification process (see Chapter 6). We recognize that a finer filter on data quality would be desirable, and should be part of the iterative revisions of this document.

Certain questions posed issues for respondents whether it was due to format or wording, and blanks were left for some TCUs in both the threats assessment and conservation effectiveness sections. This might have been avoided if we had done a sample test submitting questionnaires not just to reviewers, but also to a sub-sample of participants or researchers in the field, creating a "focus-group" approach in order to identify potential issues, such as formatting, and clarity of instructions. Unfortunately, due to a limited amount of time and resources, these steps were not taken.

This effort, imperfect as it may be in some respects, provides the first systematic effort to collect comprehensive information on tiger conservation across the range. It provides a baseline for comparison to future efforts while informing our current effort to prioritize areas for tiger conservation. Moreover it provides a measure of the success of past investments in tiger conservation to develop the information presented here.

In setting the best and most accurate conservation priorities for the tiger, this process highlighted the need for transparency and for using the best communications efforts possible to capture data and expert knowledge from those who know the tiger best. The questionnaires used were created for this project and were most likely not the most efficient means to capture data, because researchers have used alternate formats in which to enter years of data. Establishing a regular reporting mechanism that both rewards tiger researchers and conservationists through public credit for their efforts while insuring their participation through requirements attached to future tiger grants, is just the beginning of continuing the model here of documenting the status and distribution of tiger conservation and maintaining this "living document."

— Andrea Heydlauff, Eric Sanderson, Colby Loucks, John Seidensticker

2.5 Tiger Ecology: What We Know and What We Need to Know

The earliest phases of tiger conservation, and field efforts to save tigers, focused on tiger ecology: the early and continuing work initiated by the Smithsonian Institution in Nepal, long term ecological studies in Russia initiated by the Hornocker Wildlife Institute, and the extensive work on tiger ecology conducted in Nagarahole National Park, all gave us clear and important insights into the ecology of the species in a wide range of habitats. These studies, and others, are extremely well summarized in two books: Seidensticker et. al. 1999, and Tilson and Seal 1987. More recent work in Malaysia, India, and elsewhere complements the continuing work at the key, long-term study sites.

The increase in both interest and funding for tiger conservation in the 1990s, in large measure spurred by the creation of the Save the Tiger Fund, has nonetheless not seen a concomitant increase in studies on the ecology and behavior of the tiger. For all the urgent interest in tigers, the conservation community has spent relatively little time studying the ecology of tigers in the past decade. While we have made great strides in our understanding of tiger distribution and threats to persistence, we still know relatively little about tigers across much of the range of the species. In the following section we summarize some of the key ecological information we do know, and suggest important areas for future research.

Tigers are found in an astonishing variety of habitat types, including tropical lowland evergreen, dry deciduous, pine, temperate broadleaf, swamp, and mangrove, as well as grasslands in the Himalayan foothills. Their current distribution extends from south of the equator on Sumatra to the Russian Far East and from Vietnam to India. Across this huge area, they inhabit a wide range of elevations and climatic regimes. The wide habitat tolerance indicates the ecological flexibility of tigers; given enough prey and protection, it seems that tigers can thrive almost anywhere within their historic range.

The reproductive biology of tigers reflects a species capable of responding quickly to changes in the environment. In India and Nepal, females are capable of breeding at 3 years of age, have large litters (2–5 young per litter) after a relatively short gestation of 3.5 months. Their short inter-birth intervals (20 months) mean that on average an adult female produces 1.8 young per female per year. Females re-cycle quickly if a litter is lost. This results in the capacity of populations to tolerate a harvest (legal or illegal) of adult animals and to recover quickly from population crashes. Not surprisingly, some of the highest tiger densities occur in India and Nepal in areas where tigers and their prey are well protected. In the Russian Far East, Amur tiger females have smaller litters (range 1–4, mean 1.7; Smirnov and Michqelle 1999) and longer inter-birth intervals for an overall reproductive rate of 0.61 young per female per year. In spite of the more limited capacity for population growth, the Amur tiger population has grown steadily since the 1960s.

In good habitat, tigers may enjoy high survival rates. Territory holding males and females have survival rates approaching 90% per year and young have a 60% survival rate (Karanth and Stith 1999). Karanth and Stith identify poaching and loss of prey as the primary sources of mortality for wild tigers. In the absence of these mortality factors, and coupled with the high reproductive potential, tigers should be able to fill a habitat to carrying capacity relatively quickly. They argue that even small, isolated populations have low risk of extinction in the absence of catastrophes and disease. Even poaching pressure as high as 20% of the subadult and adult population appears unlikely to drive a population to extinction. Loss of prey, however, alters the dynamics of tiger populations, lowers the carrying capacity of the environment, reduces cub survival, and probably reduces the survival of sub-adults that must disperse through degraded environments.

Tiger social systems appear to be similar in India, Nepal, and in the Russian Far East (RFE). The adult sex ratio is 2.4 females to 1 male in the RFE and 3 to 1 in India/Nepal. Female home ranges are stable, but not exclusive. In both Russia and India/Nepal, females share portions of their ranges, but likely separate in space and time. The degree of overlap may reflect relatedness among tigresses; daughters may try to establish ranges adjacent to their mothers (Karanth 2001). Male ranges may encompass up to seven female ranges but three female ranges within a male's range appear more typical. In Russia, there may be more overlap among males and male ranges typically include two to three female home ranges. Tigers do patrol their territories and attempt to defend them against intruders, through scent marking, advertisement, and occasionally aggression.

After their second year, young tigers disperse from their maternal territory and attempt to establish their own territories. Mothers may make room for their daughters by budding off a part of their home range. More home ranges are available for females due to natural (and induced) mortality, and there are more female territories than male. Young male tigers must disperse and often move further than females, increasing the risk of mortality. In general mortality among dispersing tigers may be as high as 30 to 45%.

Given a cohort of 100 newborn tigers, Karanth (2001) estimates that only 20 will ever have opportunity to breed.

Although an important aspect of resilience is a measure of the tiger's dispersal capabilities, little is actually known about how tigers move, and how they are affected by fragmented landscapes (Sunquist et al. 1999). The only dataset available was collected by Smith (1993) in Chitwan, Nepal. The conclusions were that males dispersed approximately 3 times further than females and most females remained in close proximity to their mothers. Although findings indicated that dispersal distances were short, there has been evidence (some anecdotal) that tigers are capable of moving great distances (Sunquist 1981, Heptner and Sludskii 1992). In the past tigers have been documented in places that were thought to be foreign to them (the Caspian tiger was seen in steppe and desert areas), and covered great distances in relatively short periods of time (Heptner and Sludskii 1992). Today, tigers are faced with increasingly fragmented landscapes, and whose survival is negatively affected by the creation and usage of roads (Kerley et al. 2002). Although tigers might be able to move through fragmented areas, there is no doubt that connectivity plays an integral part in assisting tigers, mainly males, to survive dispersal in order to get the chance to reproduce.

Cats require cat food and tigers are no exception. Sunquist et al. (1999) speculate that the divergence and evolution of tigers within Panthera was due in part to radiation and diversification of ungulates. The relationship between tiger density and ungulate biomass is well established and consistent from India to Russia and Sumatra. Karanth and Stith (1999) models of tiger persistence indicate that prey depletion is the single biggest threat to tiger persistence in a landscape through its effect on survival in all age classes and the reduction in carrying capacity.

Although we appear to understand tiger ecology quite well in parts of India and the Russian Far East, most of our information on the natural history of tigers comes from only a few locations so we are limited in the ability to generalize. We have no ecological data for tigers from the majority of the range in Southeast Asia and Indochina. Although we are slowly developing density and population estimates (Kawanishi and Sunquist 2004), few studies examine the prey populations in conjunction with tigers, few studies use rigorous sampling schemes that allow population estimation, and few studies are examining life history parameters of tigers.

In the next decade, as we attempt to reverse trends in tiger numbers, and move from the success we have had in stabilizing and, in some cases, growing individual populations, an understanding of tiger ecology across the range of habitats in which tigers occur would be useful, if not important. However, with relatively limited resources, we understand that focusing our studies and priorities is critical. Looking forward to our next effort to design a priority setting exercise for tigers, we will want to ensure that we not only have the data we are using today with better resolution and quality, but also that we are able to take the early efforts at spatially-explicit modeling of dispersal and connectivity of tiger habitat, and apply this more broadly to make a map for the recovery and restoration of tiger populations across their range. Spatially explicit population models are useful for modeling tiger persistence in landscapes but the models are very sensitive to habitat specific demography and to dispersal estimates.

Therefore, we strongly recommend the following studies be seen as priorities for funding, or continued funding, wherever possible:

- Long-term ecological studies should continue to be supported: while they are often a significant draw on resources, these studies provide critical insights into the variation, flexibility, and resilience of tiger populations. Furthermore, they are one of the few ways that we can actually monitor, and evaluate, the direct impact of our conservation actions on that which we care most about: healthy tiger populations.

- Any spatially explicit modeling effort needs some simple, but critically hard to collect, data. We are sorely lacking in any real estimates of reproduction and survival of tigers in rainforest habitats. These habitat types support relatively low densities of tigers, and prey, and therefore present an important, and difficult conservation challenge. The rapidity with which tigers have been removed from ecosystems in Cambodia, Myanmar, and Thailand also suggests low productivity, and that restoring tigers in good habitat blocks may be much more difficult that we have previously anticipated. We just don't know.

- Increasingly, we see the establishment of large, inter-connected landscapes as essential for the recovery, and long term health, of tigers (Kerley at al. 2002). Our ability to make models that assess connectivity and persistence is rapidly improving (see Appendices), but what is lacking are data that allow us to assess the accuracy and predictive power of these models. We lack any robust data set on tiger dispersal and collecting these data across several types of habitat surely is critical to our understanding of how to retain and expand connectivity.

— Tim O'Brien, Joshua R. Ginsberg

2.6 Survey methods for tigers and prey

Making meaningful inferences about the distribution and abundance of tigers and their prey presents special challenges to wildlife biologists. Tigers are rare creatures due to their low densities in most of Asia and to their elusive habits. We often notice tigers only after they have passed through, leaving evidence detected by sign counts or photographs of a camera trap. Many prey species are also rare either because of low density, shyness of humans or nocturnal habits. Because we require reliable estimates of tiger abundance for effective conservation, and because we cannot search the entire tiger realm for evidence of their occurrence, we must be very clear and specific about our sampling targets and our sampling designs.

It is almost impossible to cover 100% area of a park or landscape during a survey for tigers or prey. In order for a sub-sample to be generalized across the landscape, sampling must be designed to accommodate inferences for the areas not visited. There are a number of books that deal with sampling issues relevant for tigers and their prey, including Karanth and Nichols 2002, Williams et al. 2002, and Thompson 2004. Systematic sampling across a study area is recommended for initial surveys aimed at determining the distribution and abundance of a species or when long-term monitoring is a goal. Adaptive sampling methods (Thompson and Seber 1996) may be appropriate when the target species are clustered in space. However, adaptive sampling can be very demanding when executed over a large area (hundreds of square kilometers for example) and search rules need to be carefully defined. Stratified sampling or sampling based on resource allocation functions may be appropriate when the study area has a range of habitats and prior information about abundance in these habitats. This is especially useful for prey surveys or in areas where the probability of detecting tiger occurrence is habitat dependent.

The most basic data we can collect during surveys of tigers and prey is presence/absence data, or more accurately detection/non detection data—in which we attempt to determine the probability that a habitat unit is occupied. Patch-occupancy models (MacKenzie et al. 2002) are based on multiple visits to a sub-sample of habitat units. They have the advantage of being able to use any sign as evidence of presence. Estimation of occupancy does not require identifying individuals and may be especially useful when the objective of the survey is the determination of the extent of a species occurrence. It may also play a role in the estimation of abundance of territorial species.

Capture/recapture methods have been demonstrated as a useful tool for the estimation of tiger abundance and density (Karanth and Nichols 2002). In their most basic form, all population estimation techniques are a means of relating count statistics from a portion of the study area to population size using a constant of proportionality (detection probability) that relates the count to the population estimate. The capture/recapture sampling approach allows the estimation of detection probabilities through the use of individual identifying marks such as photo IDs from camera traps, DNA from scat, or the scent of tigers identified by trained dogs. The key to success in population estimation is to maximize the detection probability either by locating camera traps in areas of high activity based on prior knowledge of tiger activities, or use of baits to attract tigers to traps. The programs CAPTURE and MARK offer a number of estimation procedures based on the nature of the detection probability (uniform, varies by individual, varies over time, etc). It is also possible, under certain circumstances, to borrow estimated detection probabilities from other studies and apply them to data samples that are inadequate to estimate capture probabilities because of low recapture rates.

New advances in DNA fingerprinting offer the possibility of estimating abundance based on non-invasive sampling of hair, feces, or feathers. The DNA serves as an identification marker that is as useful as a photograph. The technique requires the isolation of sufficient quantities of high quality DNA and development of nDNA or mtDNA microsatellite markers. Sample preservation, properly incorporating the probabilistic identifications into the capture recapture analyses, the determination of the sampled area, and addressing the population closure assumption remain issues to be resolved, but the technique holds great promise.

Line transect estimation based on distance sampling remains the most common method of estimating ungulate prey populations. Like capture/recapture, distance sampling offers a method of relating count statistics to population size based on detection probabilities. Detection probabilities are expected to decline as distance from the transect increases and the key to distance sampling is modeling the distribution of perpendicular sighting distances (detection function) appropriately. The area sampled is also incorporated using the length of transects and perpendicular distances. Line transect surveys may be used for individuals or for clusters of individuals. They may also be used for dung or pellet counts when data on dung decay rates are available. The program DISTANCE allows for modeling of the detection function and the ability to choose between alternative models.

In some situations, it may only be feasible to use indices of population size rather than actual estimates to make inferences about the relative abundance of animals. The utility of such relative abundance indices rests on the basic assumption that there is some monotonic relationship between the abundance and the index usually described by a proportionality constant (such as a detection probability). The more we know about the nature of that relationship, the more useful the index. A second challenge for the successful use of abundance indices is the assumption that the probability of detection is constant between two time periods. This means that changes in the index between time 1 and time 2 represent changes in abundance rather than changes in detection or some other form of bias. Standardization of survey methods and data collection may minimize sources of bias in relative abundance indices. Generally indices are more useful to compare abundance across time (e.g between years) rather than across space (e.g. between landscapes). However, in cases where environment or habitat may affect the form of the relationship between the index and true abundance, the use of co-variates in an analysis of variance framework may be a useful method for reducing bias.

— Tim O'Brien, Ullas Karanth

Chapter 3 Land Cover Data for Tiger Conservation Landscapes

3.1 Objectives for Land Cover Mapping

Fragmentation, degradation and destruction of intact landscapes ultimately lead to habitat loss and are among the gravest threats to tigers. Habitat losses probably have been dramatic at regional and local scales (e.g. FAO 2003), yet their extent has not been quantified for most of the tiger's geographic range. Even the most basic land cover maps necessary to determine the extent of remaining tiger habitat are difficult to acquire and frequently unavailable for conservation assessments. One objective for our revision of the TCUs is to compile the best, most recent information available on land cover in the tiger's geographic range.

While definitions may be cumbersome, our use of the term land cover, rather than habitat, is important. Land cover type describes the earth surface feature that can easily be mapped from satellite imagery or aerial photography. Usually land cover types represent major habitat or land use types, such as forest, grassland, wetland, agriculture, and urban. Strictly speaking land cover type is different from habitat, because habitat may encompass features such as prey abundance that cannot easily be mapped using aerial photos or satellite imagery.

3.1.1 Methodology for Assembling Data

By contacting organizations and specialists in range countries, we compiled currently available land cover data sets for the tiger range. Two general types of data exist for compilation of a tiger habitat map: land cover maps derived from recent Landsat satellite imagery (e.g., Leimgruber et al. 2003, 2005), and coarse resolution regional land cover data sets based on 1-km AVHRR or MODIS satellite data (e.g., Loveland et al. 1991, Friedl et al. 2002) (Table 3.1).

Sensor name	Resolution		*Radiometric resolution*
	Spatial	Temporal	
Landsat TM/ETM+	15-30 m	16 days	7 multispectral bands, 1 panchromatic
Advanced Very High Resolution Radiometer (AVHRR)	1,000 m	12 hours	3 multispectral bands
Moderate Resolution Spectroradiometer (MODIS)	250-1,000 m	1-2 days	32 multispectral bands (3 useful for land cover)

Table 3.1 Overview for characteristics of common satellite sensors

Different types of satellite imagery have been widely used for mapping land cover at regional and local scales. These tend to vary in spatial resolution (i.e. the grain of the image), temporal resolution (how frequently they can take an image of the same spot on earth), scale (the area covered by an image), and radiometric range (the range of electromagnetic radiation they record). Table 3.1 provides a basic overview of three of the more commonly used sensors for broad-scale land cover analysis.

All these land cover sets were created for different purposes and, thus, are varied in data format (vector vs. raster data), spatial extent, coordinate systems, spatial resolution, and habitat categories. To combine all data sets into a single map of the entire tiger range, we integrated all land cover categories into a reduced and common set of major land cover types (Table 3.2). In addition, we converted all data into 1-km raster format and projected them to an equal area projection for accurate calculation of TCU areas. We used a Lambert Equal Area Azimuthal projection with a central meridian at 110**E** and reference latitude of 30**E**. A more detailed description of the methods used to integrate different data sets can be found in Appendix 5.

Land cover category	**Area (km^2)**
Water	278,417
Wetland	40,516
Swamp/inundated	35,718
Forest	131,832
Evergreen forest	1,043,650
Deciduous forest	1,896,623
Mixed forest	1,519,830
Mangrove forest	17,713
Degraded forest	59,615
Savanna	1,241,001
Scrub	1,416,863
Degraded scrub	1,880
Bamboo	3,615
Grassland	1,408,364
Plantation	38,099
Agriculture	6,769,100
Barren	667,703
Transmigration site	5,205
Urban settlement	35,567
Mining/industry	470
Snow/ice	2,733
Total	**16,614,514**

Table 3.2 Common set of major land cover types used to integrate data from different areas within the historic tiger range.

3.2 What We Have Learned About Remaining Tiger Habitats

3.2.1 Little high-resolution land cover data is available for the tiger range.

High-resolution land cover maps for the tiger range—based on 28.5 or 30-m resolution imagery from Landsat or a similar quality sensor—were hard to come by. We received detailed data for only 6 regions: the Russian Far East; Sumatra; the central highlands of Vietnam; and Laos, the Mekong River basin, Myanmar, and the Terai Arc in Nepal, covering approximately 11% of the historic tiger range (Figure 3.1, Table 3.3).

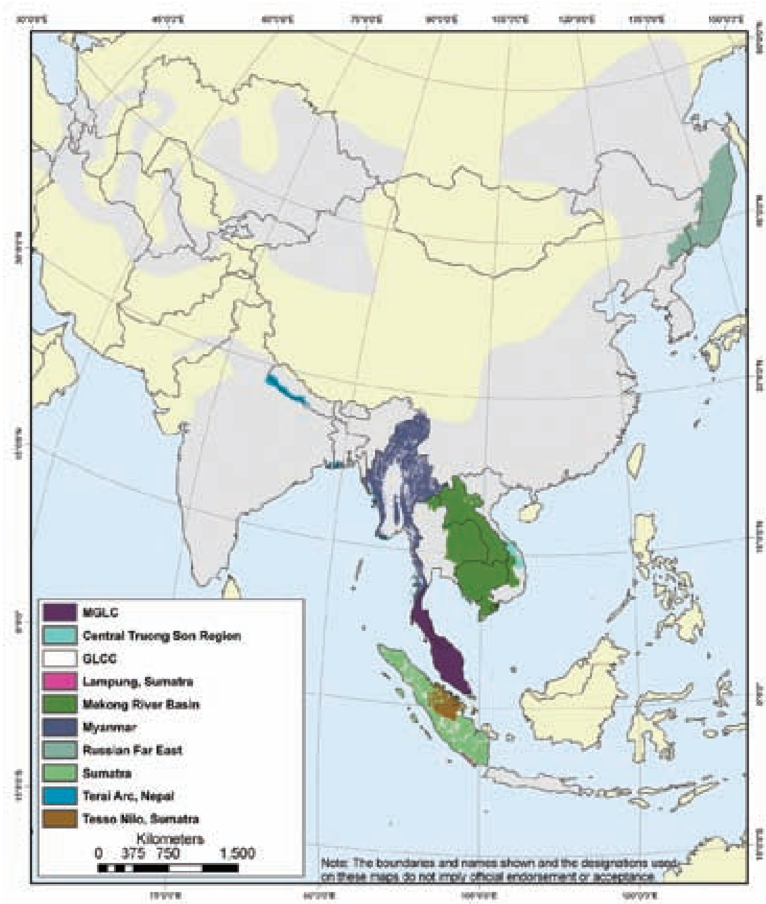

Figure 3.1 Spatial coverage of different land cover data sets used in the compilation of tiger land cover. For more information on sources, resolution, and accuracy of data sets see Table 3.3.

For all other areas we had to rely on the Global Land Cover Characterization (GLCC) map from 1992 and the MODIS Global Land Cover (MGLC) from 2000—two existing coarse-resolution land cover maps. Additional information from tiger experts indicates that other, high-detail, land cover maps are available for parts of India and Malaysia. However, we were not able to locate or acquire these data.

Currently there are two global land cover data sets commonly used for regional analyses, the GLCC 1992 and MGLC 2000. The GLCC was created from 1-km AVHRR data acquired in 1992 (Loveland et al. 1999). The MGLC is based on Moderate Resolution Imaging Spectroradiometer (MODIS) imagery from 2000 (Friedl et al. 2002). While the latter data set is more recent and has a finer spatial resolution (0.5 km for MODIS vs. 1 km for AVHRR), initial analyses indicate that forest areas in the MGLC are severely overestimated with the exception of southern Thailand and peninsular Malaysia. Based on our own knowledge of forest in Asia, the older GLCC map is a more accurate representation of the current conditions throughout the rest Asia, despite its greater age and lower resolution. Thus, we used GLCC for all areas in Asia not covered by fine-resolution data and not including southern Thailand and peninsular Malaysia. Based on experts reviews we found that MGLC provided the best approximation of land cover conditions in the latter two areas.

Most land cover maps have accuracies between 80 and 90%. Thus, even broad-scale changes resulting in the loss of 10-20% of land cover might go undetected. Based on this observation, it is justified using the GLCC for regional analysis. However, at local scales (e.g. a single TCU), habitat assessments should be conducted using recent, high resolution data.

Area	Date	Source data	Source data date	Data type	Spatial resolution (m)	Source	Analyst	Accuracy	Mapping Technique
Russian Far East (Primorsky and Khabarovski Krai)	2004	?		Vector	?	TIGIS, Institute of Geography FEB RAS, WCS	?	Assumed high	
Sumatra	?	Landsat TM	2000	Vector	30	Indonesian Ministry of Forest	Martin Hardiono		
Tesso Nilo-Bukit, Tigapuluh, Sumatra	?	Landsat TM	2000-2001	Vector	30	WWF Indonesia	Martin Hardiono	Assumed high	Digitizing from satellite imagery
Part of Lampung, Sumatra	?	?		Vector	?	WWF Indonesia	Elisabet Purastuti	Assumed high	
Central Truong Son region, Vietnam and part of Laos	?	Landsat TM	2000-2001	Raster	30	Am. Museum of Natural History's Biodiversity Conservation	Ned Horning	accurate (no final test yet)	Supervised classification
Mekong River basin	?	Landsat TM, topographic maps	1996-1997	Raster	250	Mekong River Commission, WWF Laos, Cambodia	?	90%	Visual interpretation
Myanmar	2004	Landsat TM, ETM+	1990-2000	Raster	30	Smithsonian Institution, CRC	Leimgruber et al. (2005)	86%	Supervised Classification
Terrai Arc, Nepal	2003	Landsat TM	2000-2001	Raster	28.5	WWF, University Of Minnesota, Hunter College, NORAD	Anup Joshi M. Shrestha S. Ahearn David Smith	90%	Unsupervised & supervised classification
Southern Thailand, mainland Malaysia, southern India	2000	Spot 4	1999-2000	Raster	1 km	Joint Research Centre	H.-J. Stibig, R. Upik, , S. Mubareka, & R. Beuchle, C. Giri	Assumed high	Unsupervised & supervised classification
All remaining areas	1997	AVHRR	1992-1993	Raster	1000	Global Land Cover Characterization (GLCC), USGS	Loveland et al. (2000)	78.7%	Unsupervised & post classificatio[illegible] stratification

Table 3.3 Habitat and land cover data used for the new tiger habitat map.

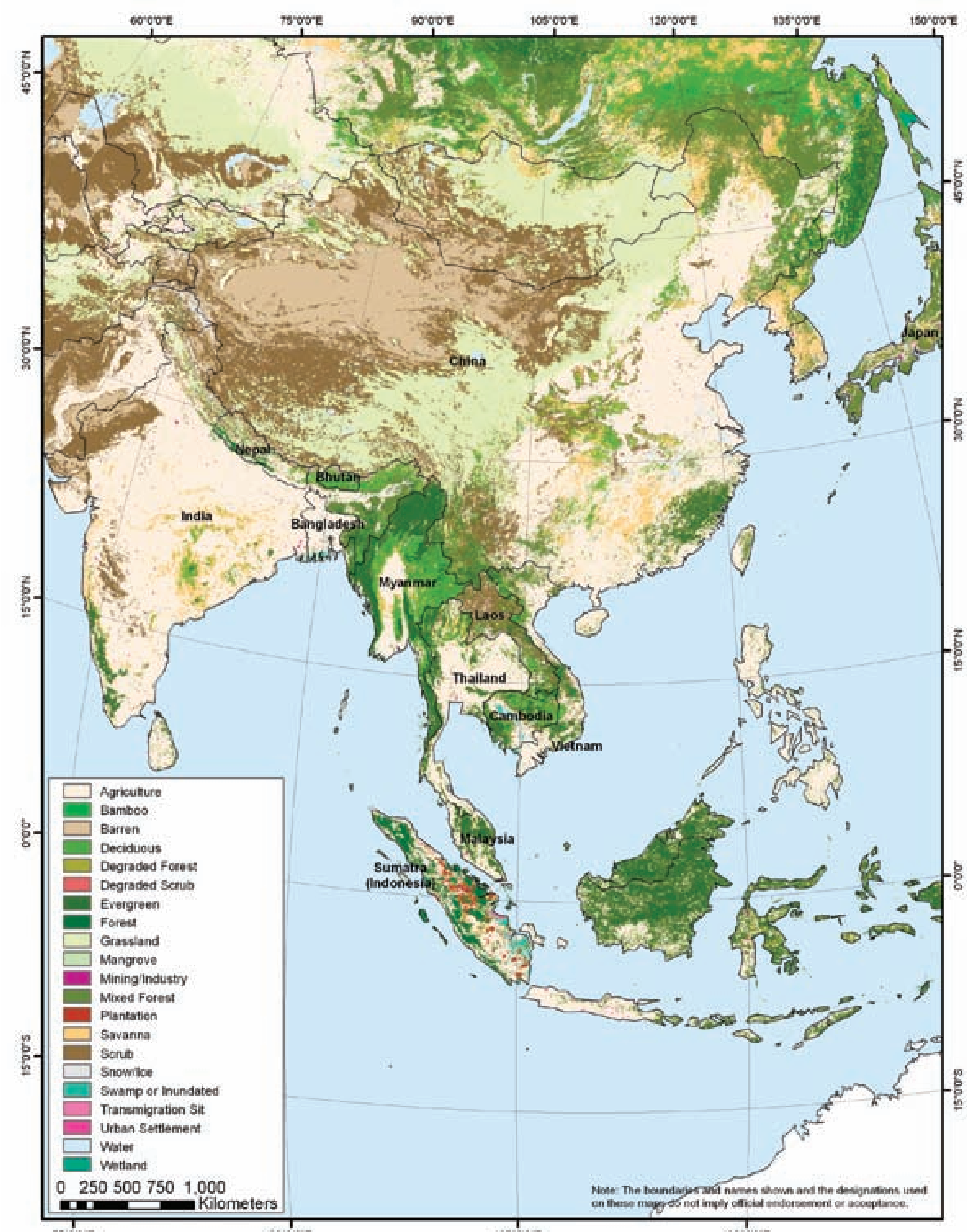

Figure 3.2 Land cover in historic tiger ranges (see Appendix 5 for land cover types that potentially represent appropriate structural land cover for tigers).

3.2.2 Currently available land cover is an approximation of remaining tiger habitat

Roughly 43% of the historic tiger range is still under land cover that may present good tiger habitat (Figure 3.2, Table 3.4). However, when analyzed at finer scales much of this land cover may prove not to represent actual tiger habitat. Land cover data derived from satellite imagery cannot provide information on human activities unless these significantly disturb the canopy. Also, land cover data has limited value for deriving an index of prey availability—one of the most important habitat variables for tigers. The level of human disturbance and the availability of prey can be incorporated in the TCU mapping via other auxiliary data sets (e.g. the Human footprint analysis we use in Chapter 4 and Chapter 5).

Potential for tiger habitat	**Area (km^2)**
Structural Land Cover	7,199,606
Marginal Dispersal Zone	9,414,908
Total	16,614,514

Table 3.4 Land cover as it relates to potential tiger habitat (see Appendix 5 for a classification of major habitat types by tiger potential).

3.2.3 Using actual land cover data changed perception of Tiger landscapes significantly

Using the newly created land cover map for the tiger range has significantly changed how we perceive remaining tiger landscapes. The landscapes now consist of many patches that are considerably different from the original TCUs. However, the new maps are a more accurate representation of the patchiness, configuration, and connectivity of potential tiger habitat in the tiger landscapes. This is not surprising considering the conceptual differences between the new land cover map used in our analysis and the WCMC map used in the TCU 1.0 exercise. The WCMC map of Asia was created using a combination of techniques, ranging from delineating habitats from 4-km satellite data, and from utilizing elevation and climate data, to relying on expert knowledge to digitize major habitats. This combination of techniques produced the best available habitat data at the time of the TCU 1.0 analysis, but accuracy was reduced because of the varying quality of the expert knowledge. The new land cover map is entirely based on analysis of multi-spectral data to separate different major habitat types. Hence, any comparison of the new land cover map with the original WCMC map is of limited value. Differences do not indicate increases or decreases in specific habitat types, i.e. tiger habitat losses or gains, but rather are indicative of an improved ability to delineate habitats more accurately.

3.2.4 Few data are available to determine how much tiger habitat has been lost and where

Except for the Smithsonian (SI) forest cover maps of Myanmar (Leimgruber et al., 2003, 2005), we were not able to access data set that specifically assess habitat loss within the tiger range. Even the Smithsonian data set provides only information on forest cover, not on other important non-forest habitats. That study shows that large forested tiger ranges in Myanmar have experienced minor habitat loss (>0.3% annually). However, mangroves and dry forests—a potential tiger habitat elsewhere in the range—declined dramatically in some areas, with up to 20% losses over a 10-year period.

3.3 Conclusions

We were able to compile a new regional land cover data set for the tiger range. This map represents a significant improvement over the WCMC map used during the first TCU analysis. Because of significant advances in satellite remote sensing, geospatial analysis technology, and information technology, one would assume consistent information on habitat extent and changes during the past 10 years is available for all of the tiger range. Unfortunately this is not true. No consistent high-resolution land cover data set exists that spans even significant portions of the tiger range. What is available are data from individual studies, frequently conducted with different goals and not specifically designed to detect tiger habitat or to quantify changes in tiger habitat. Even these more detailed maps cover only 11% of the tiger range.

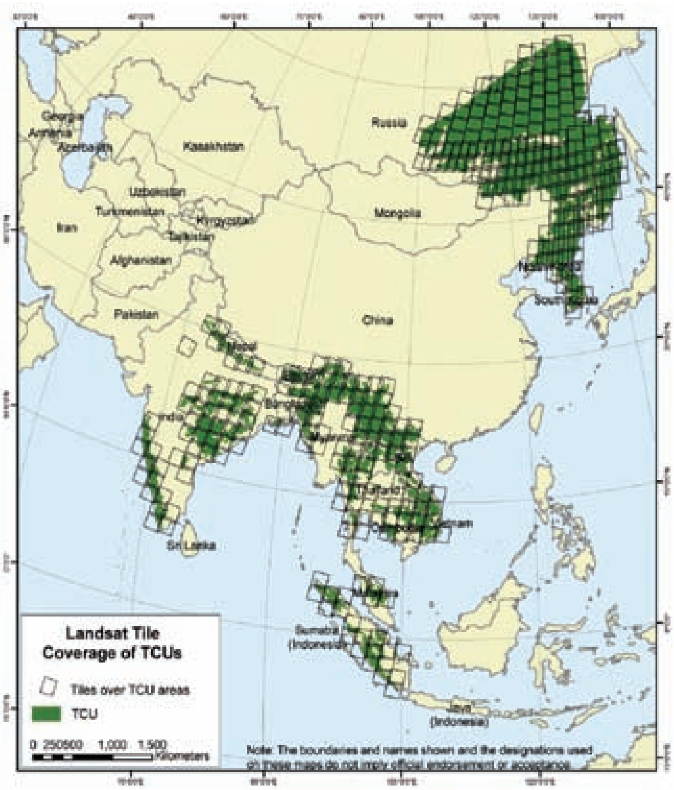

Figure 3.3 Landsat tiles required for improved analysis of current tiger range

This newly developed land cover data for the tiger range can serve as a baseline assessment, but we urgently need to update this map with new satellite imagery (see Figure 3.3 for key areas). To achieve better monitoring of tiger habitats and changes to these habitats we need:

1) repeated (every 5 years), wall-to-wall satellite imagery for all TCUs;

2) standardized analysis/classification of these satellite images into land cover categories and, if possible, tiger habitats;

3) time series of satellite images to determine the rate of habitat loss in different parts of the tiger range.

— Peter Leimgruber, Melissa Songer

Chapter 4 Delineating Conservation Landscapes

4.1 Introduction

In the 1997 TCU 1.0 document a tiger conservation unit (TCU) was defined as "a block or cluster of blocks of existing habitats that contain, or have the potential to contain, interacting populations of tigers" (Dinerstein et al. 1997). This definition enabled a geographic information system (GIS) analysis based on tropical forest cover maps newly available from the World Conservation Monitoring Center (MacKinnon, J. 1997). TCUs were prioritized based on their size, presumed connectivity to each other and expert assessments of threats and population status. Importantly, areas where there was no or little information on tigers, but appeared to have habitat, were classified as "priority for survey." Areas in China and Russia with tigers were excluded, as were areas in central Asia from which tigers had been extirpated. The 1997 effort was highly successful in drawing attention and funding for field-based conservation of tigers, creating much of the information that fuels our current efforts.

Since that time, we have learned a lot about tiger status and distribution. Many of the "priority for survey" areas have now been surveyed, confirming tiger presence in places like Melghat, Panna, and Kazaranga in India (Chundawat and van Gruisen 2004, Karanth et al. 2004b), but not in vast areas of Myanmar (Lynam et al. 2003) and China (Tilson et al. 2004). Research in the interim has revealed the importance of prey populations for defining tiger habitat, rather than a strictly structural definition (for example, based on vegetative cover). New research techniques have also been developed and formalized that allow for improved estimation of tiger densities using infrared camera traps and capture-recapture estimation techniques (Karanth and Nichols 1998). In the past 10 years, conservation measures have increased in parts of the tiger's range, which has been critical for securing tiger populations in some areas; still, tigers remain under grave threat in many other parts of their range.

Entering this priority-setting exercise our information base now consists of:

1) a systematic collection of tiger observation localities from the last 10 years (see Chapter 2);

2) a systematic survey of tiger researchers about the current status of TCUs (see Chapter 2)

3) ecological estimations of tiger densities specific to habitat-type;

4) an improved land use/land cover layer (see Chapter 3);

5) a global dataset on human impact, which can be used to compare human impact from one part of the range to another (Sanderson et al. 2002); and

6) a global dataset on habitat types (Olson et al. 2001).

Each of these inputs represents an improvement over the data available in the past, but all of them have problems. As described earlier in Chapter 2, the tiger localities and TCU survey suffer from a not-entirely satisfactory return rate of surveys sent to members of the tiger research and conservation community, while the land cover/land use dataset has been assembled from local, regional, and global datasets (Chapter 3), depending on what was available per region, many of which have localized problems. Despite these shortcomings, these datasets enable us to take a more sophisticated approach to defining tiger conservation units than was previously available.

Over the same period, the art and science of conservation planning has also advanced. Building on TCU 1.0, in 1999 the Wildlife Conservation Society and partners conducted a data synthesis and priority-setting exercise for the jaguar (Sanderson et al. 2002). The jaguar study effectively incorporated lessons learned in the first TCU exercise while adopting several new methods as well. First, it provided a data structure that encompassed all of the historical range of the species, recognizing the importance of keeping the historical range as a baseline. Second the method built on the "priority for survey" areas of the first TCU exercise to acknowledge upfront areas where knowledge exists and where it doesn't, as measured across the community of jaguar experts. Known areas of the jaguar range were subdivided into areas of presence and areas of breeding populations suitable for long-term conservation efforts. Third, the jaguar exercise incorporated point locality information into the data synthesis as an independent check against the experts' informed opinions of areas. Fourth, as with the first tiger exercise, the jaguar study maintained the importance of eco-geographic variation in tiger populations as the basic unit for priority-setting; that is, in order to a save a species, it is important to identify and conserve populations of the species in all the important habitats and regions where it occurs across the range. Fifth and finally, the methodology provides a classification system that completely tessellated the historical range of the species, so that all parts of its range are named as part of a global strategy for species conservation. This method has subsequently been adapted for other species, including the American crocodile, Mongolian gazelle, and African lion.

For the purpose of defining tiger conservation units in this new assessment, it is important that they fit within both short-term and long-term conservation strategies for tigers. In the short-term it is critical to acknowledge that tigers are still endangered across most of their range, therefore identifying and conserving existing populations is the first step toward long-term success. Over the long-term however, ensuring that existing small populations survive is insufficient; we need to move toward conservation that provides the opportunity for re-colonization of extirpated areas, connectivity between populations, and larger, more robust populations if we are to meet our goal of 100,000 tigers across the historical range by 2100.

4.2 Component Parts of a Range-Wide Tiger Conservation Strategy

To set spatial priorities across the tiger's range, we sought to divide the region into the most meaningful units for tiger conservation investment at the regional scale. This first required that we define categories that are most appropriate for this purpose. These categories were then further refined to work within the constraints of the limited, and often imperfect, information that was actually available to map these areas. From our tiger database we were able to draw certain conclusions about where tigers are confirmed to be present or absent, areas where we know tigers have been breeding recently, and areas we know have been extirpated due to human activity. For most of the remaining areas across the range, we lacked tiger survey information—for these places we were forced to make assumptions about tiger presence, absence, or their continued unknown status based on help from our tiger, land cover, and human impact datasets.

Using all information available to us, we divided the tiger range into landscapes, which represent the minimum unit for regional-scale investment and management (acknowledging that local-level investment and management is often conducted at a smaller scale). The name "landscapes" reflects an important change in management area definitions from TCU 1.0, where tiger habitat was categorized into tiger conservation "units." The term landscape reflects that tigers are essentially "landscape species" (Sanderson et al. 2002), using large, heterogeneous areas where multiple biological habitat types as well as many different kinds of human uses often apply. Landscapes delineated in this new assessment are grounded firmly to a revised definition of "habitat," which suggests that suitable habitat consists not only of land cover that is suitable for tigers (as in TCU 1.0), but with sufficient prey as well (Karanth et al. 2004b). Because we lack adequate range-wide information on prey abundance, we used range-wide human impact indices as a rough surrogate for the likelihood of sufficient prey.

Accordingly, we developed the following definition of a Tiger Conservation Landscape for this analysis:

A Tiger Conservation Landscape (TCL) is a block or cluster of blocks of habitat[1] meeting a minimum size threshold specific to habitat-type[2], where tigers have been confirmed to occur in the last 10 years and are not known to have been extirpated.

A TCL has the following attributes:

- A TCL has evidence of one or more tigers over the last 10 years;
- In accordance with the first delineation, a TCL can consist of several adjacent blocks of habitat among which tigers can disperse, up to a distance of 4 km, which is considered the approximate threshold of non-habitat that tigers will cross (Dinerstein et al. 1997);

[1] "Habitat" as referred to here is "effective potential habitat", or suitable land cover of low human impact

[2] "Habitat-type" refers to major habitat type defined by ecoregions. Examples include "tropical grasslands" and "temperate mixed forests".

- Also in accordance with the first delineation, a TCL need not be restricted to nor contain protected areas, but instead includes the entire landscape over which tigers may disperse and become established (Dinerstein et al. 1997);
- A TCL must meet a minimum core area requirement for its largest block of habitat that is specific to the habitat-type in which it is found. Area requirements are based on known ecological tiger densities;
- TCL boundaries are defined either where habitat ends with no suitable habitat within 4 km for the tiger to disperse to, or at country or ecoregion boundaries.

This definition maintains a parallel structure with the previous definition while including the additional critical constraint that TCLs are known to have tigers in them. Our definition of habitat is based on a combination of what we know about structural land cover and human factors, and rests within the logic that habitat must by definition have sufficient prey, and that human factors and prey are usually inversely related.

This definition incorporates the optimistic spirit of TCU 1.0 by considering adjacent habitat as ecologically important. Including adjacent habitat is critical: If the first step in the next tiger strategy is to secure existing tiger populations, the second step is to secure their connectivity to each other. Moreover, adjacent habitat areas within the TCLs serve

Term	Definition
Structural Land Cover	Land cover visible on satellite image that is considered suitable for tigers to complete all stages of their life cycle. It provides breeding areas, prey, and some form of shelter. Examples of structural land cover include certain forest types and tall grasslands. Also called "suitable land cover."
Effective Potential Habitat	"Structural land cover" of low human impact. Because areas of low human impact are assumed in this analysis to be more likely to have adequate prey, this is considered true "habitat" for tigers. Also called "habitat."
Non-habitat	Areas that do not have "effective potential habitat" either because they do not have structural land cover or because they are of high human impact. Non-habitat includes but is not limited to "unsuitable land cover."
Unsuitable land cover	From satellite image classification, land cover classes that do not offer suitable habitat for tigers (defined as security, prey, and breeding area). Unsuitable land cover types include agriculture, plantations, and urban areas. Unsuitable land cover is one type of "non-habitat." Also called "dispersal zone."
Habitat-type	These include tropical forests and temperate grasslands, with the significance that different habitat-types have different levels of productivity that affect prey abundance and subsequently, tiger density. Habitat-types and defined in this model by groups of ecoregions. We calculate for each habitat-type the minimum area necessary to support five female tigers, based on results of field research studies undertaken in that or similar habitat-types.
Landscapes	Agglomeration of habitat blocks that are within 4 km of each other. Landscapes incorporate areas of non-habitat, their largest habitat block meets a minimum area requirement specific to the habitat-type where the landscape is found, and the management designation is defined by the absence or results of tiger survey in the past 10 years. Landscapes include Tiger Conservation Landscapes, Survey Landscapes, and Restoration landscapes.

Table 4.1 Tiger habitat glossary

as a buffer to threatened populations. Including adjacent non-habitat within proximity of habitat patches is important for reestablishing connectivity between and among tiger habitat patches. Because the concept of habitat is key to delineating the landscape, we provide a brief glossary of definitions in Table 4.1. Terms defined in this table will be further discussed later in this chapter.

In addition to designating areas where tigers are known to occur, we also provide management designations to areas outside TCLs. Within the current tiger range, three additional designations are important:

Restoration Landscapes Large areas of structural land cover under low human influence where survey efforts since 1995 have not revealed evidence of tigers.

Survey Landscapes Large areas of structural land cover under low human influence where tiger status is unknown. To our knowledge, these areas have not been surveyed since 1995.

Fragments with Tigers Small areas of structural land cover of low to high human influence that show evidence of tigers. These areas are too small to meet the minimum area requirement to be TCLs, but are important nonetheless for supporting the tigers that live there.

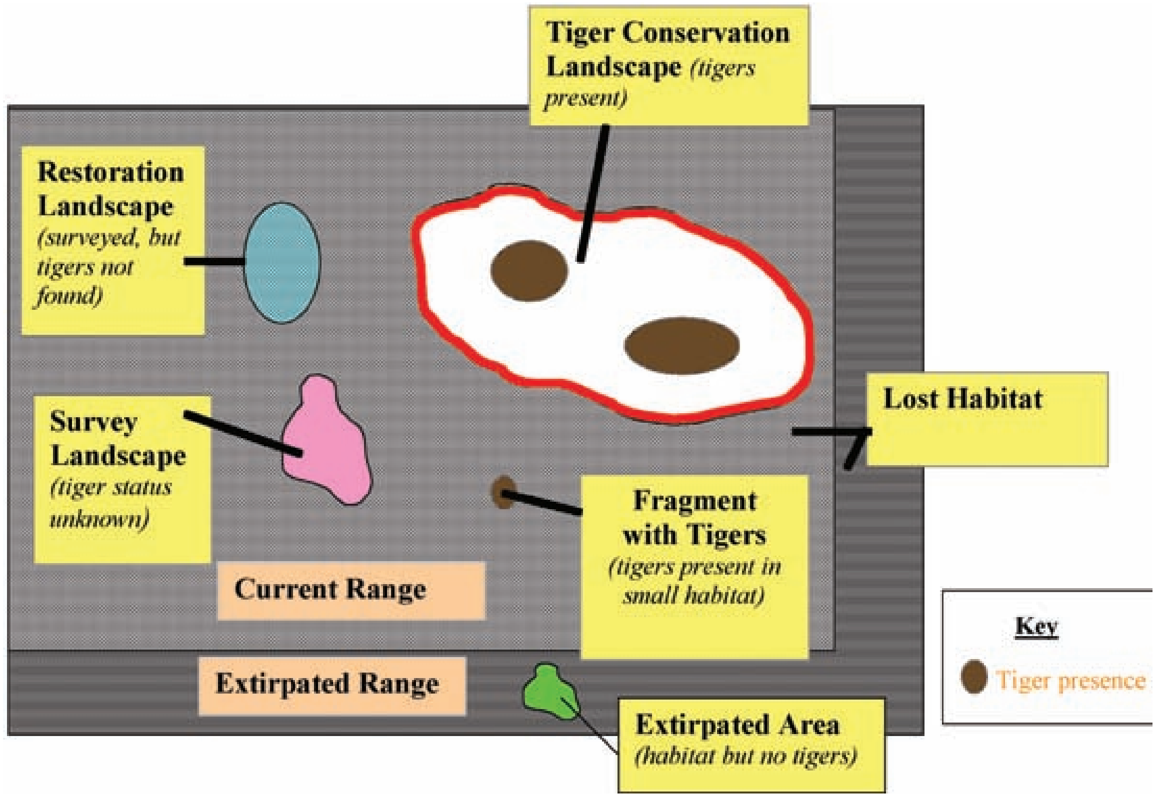

Figure 4.1 Schematic diagram of the delineation results

In a similar manner, we classify remaining habitat outside of the current range into "Extirpated Landscapes." Extirpated Landscapes include large areas of habitat in China and central Asia, and small habitat blocks on the island of Java. Extirpation in some of these areas is recent, in some cases within the last 20 to 50 years.

All remaining areas of both the current and extirpated portions of the tiger's range are categorized as "Lost Habitat." These areas do not meet the criteria necessary to be a landscape or Fragment with Tigers. Included in this category are areas either lacking structural land cover for tigers and effective potential habitat in blocks too small to support tigers.

The definitions above help support components of a comprehensive tiger strategy aimed at the long-term, which include research and survey, restoration, and recognition of some areas that have been removed from the tiger's range. Together they allow us to comment on the status of tigers in all parts of the tiger's historical range. A schematic of the results is provided in Figure 4.1.

4.3 Methodology for Delineating TCLs

The delineation of TCL 2.0 incorporates four main inputs not available at the time of TCU 1.0: new tiger distribution data; a new land cover classification; human influence measures; and tiger density information by habitat-type. Other range-wide datasets incorporated into the delineation were data on the historical and extirpated tiger ranges, elevation, ecoregion, and country boundaries. In this section we describe how these datasets were analyzed to produce the tiger landscapes (Figure 4.2 and Table 4.2).

In summary our methods include the following sequential steps:

1) Define the historic tiger range as the study extent.

2) Assign "structural land cover" based on the land cover data.

3) Map effective potential habitat by excluding high human influence areas.

4) Reconnect areas through connectivity (dispersal) analysis and filter to minimum habitat sizes.

5) Apply tiger data and assign area designations.

6) Merge "areas" into "landscapes."

7) Map extirpated range.

A priori decision rules were developed based on the best available ecological information available to us. We developed a GIS program written in an Arc/AML script to automate the delineation process in order to incorporate updated datasets, to vary parameters to achieve the most accurate results (see Chapter 5), to add new decision rules, and to respond to comments from tiger experts.

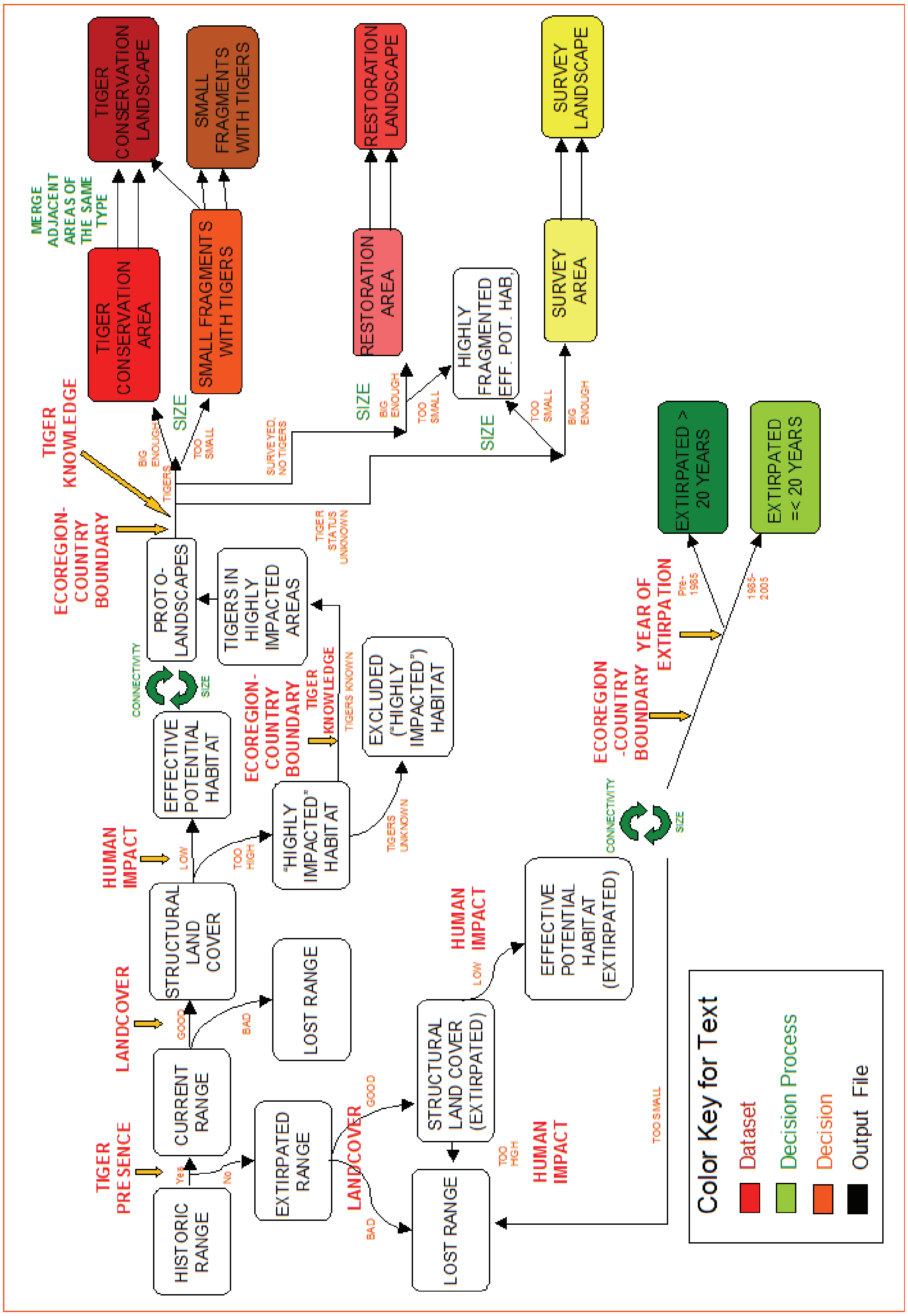

Figure 4.2 Process used to delineate landscapes

Variable	Setting
Tiger historical range	IUCN Modified (Nowell and Jackson 1996 and Mazak 1981)
Extirpated areas	Tiger working group[1] (based on Nowell and Jackson 1996 and TCD2005)
Land cover classification	Land cover basemap compiled from 10 input land cover grids (Tiger Working group) Each land cover-elevation combination coded as either structural land cover or non-habitat
Known tiger survey locations	TCD2005. Points selected for most recent and non-provisional data-sources. Variable radius of 3-14 km^2 around point locations in relation to tiger density at the habitat-type.
Elevation	3350 m maximum
Human impact	Human Influence Index (HII) < 16 to select as habitat those areas of low human impact
Boundaries to divide landscapes	Ecoregion by Country Boundaries
Dispersal capability	4 km between habitat patches
Minimum core habitat and stepping stone areas	*Minimum core area:* Big enough for 5 tigers (minimum area varies depending on habitat-type) *Minimum stepping stone size:* 10% of minimum core area (size varies depending on habitat-type)

Table 4.2 Variable settings selected to delineate tiger landscapes
[1]Tiger working group refers to the co-authors of this study - WCS, WWF and SNZP

4.3.1 Define the historical range as the study extent

The extent of our analysis is the historical range for tigers, circa 1850. We developed this map by digitizing the historical tiger range from Nowell and Jackson 1996 and modifying it slightly in India and Pakistan to better reflect the cited accounts of tiger locations. It is worth noting that some areas of the range lost their tigers no more than 20 to 50 years ago, including areas in China and central Asia. We chose to use the historical range as a baseline for this analysis as a reminder that less than 100 years ago, the tiger had a much larger range: conservation efforts should reflect this. Once the historical map was completed, we clipped all range-wide datasets to the historical range.

4.3.2 Map structural land cover from land cover classification

We began with the land cover dataset described in Chapter 3 (see Figure 3.2), and assigned each land cover category to either a structural land cover or dispersal zone class (see Chapter 3):

- ***Structural land cover*** Land cover that potentially provides security, prey, and breeding conditions, as inferred by satellite image classification;
- ***Dispersal zone*** Land cover that provides little to no security and prey.

For the purposes of this analysis, we used structural land cover as the first element to delineate the landscapes, and the dispersal zone (also called "non-habitat") as undifferentiated dispersal areas (Figure 4.3). The exact assignments of land cover classes to tiger habitat is provided in Appendix 5.

We assigned all structural land cover above 3,350 meters, all of which is found in the Himalayan mountain chain, to the non-habitat category. This elevation has been selected to correspond geographically with the highest areas in the Himalayas that tigers are believed to be resident, based on evidence of breeding data in the tiger database (TCD)[3].

We refined the grassland and scrub vegetation classes with elevation thresholds. Montane grasslands above 2,000 meters altitude were re-classified from structural land cover to non-habitat. Tigers do not utilize these high elevation grasslands to the extent that they use lower elevation grassland habitat (Seidensticker pers. comm. 2005). For similar reasons, we also reclassified scrub vegetation higher than 2,000 meters elevation to non-habitat.

A filter was applied across the structural land cover map to exclude patches less than 5 km^2 (effectively creating a minimum mapping unit of 5 km^2 for the analysis).

Structural land cover for tigers ideally includes the following three basic elements: (1) Security is defined as the ability of tigers to survive in a variety of ecosystems and with limited threat of persecution; (2) Prey-base is the ability of the land cover type to support populations of major prey species that form the basis of the tiger's diet; and (3) Breeding areas represent those ecosystems where both security and prey-base are at sufficiently high levels as to allow for successful breeding and rearing of offspring. Satellite-based land cover mapping is insufficient to verify that all of these conditions have been met, so we next applied a human influence measure to exclude areas that appear to have habitat, but are unlikely to support tiger populations.

4.3.3 Map effective potential habitat by excluding high human influence areas

Human presence, in addition to land cover, has a significant influence on the distribution of tigers, with impacts that range from hunting of the tiger's prey base, to direct persecution of tigers, to human infrastructure development. Often an area that looks like suitable habitat from a satellite image will be devoid of wildlife because of human impact, which has been dubbed the "empty forest" phenomenon (Redford 1992). To avoid overestimating tiger habitat, we incorporate the Human Influence Index (HII), a precursor to the Human Footprint dataset (Sanderson et al. 2002), into the analysis. The HII is composed of the weighted sum of human population, land use, and power infrastructure datasets and scores each 1 km^2 pixel throughout the globe on a scale of 1 to 72, with 72 reflecting the highest human influence (Figure 4.4).

In order to determine the HII threshold important to tigers, we compared the average human influence values of points where tigers have been found ("presences"), and points where tigers have not been found ("putative absences"), to the overall distribution of

[3]3,350 m may not be the precise elevation up to which tigers are actually resident, but given the shortcomings of the elevation dataset, this is the value we selected based on geographic correspondence between elevation and evidence of tigers breeding data.

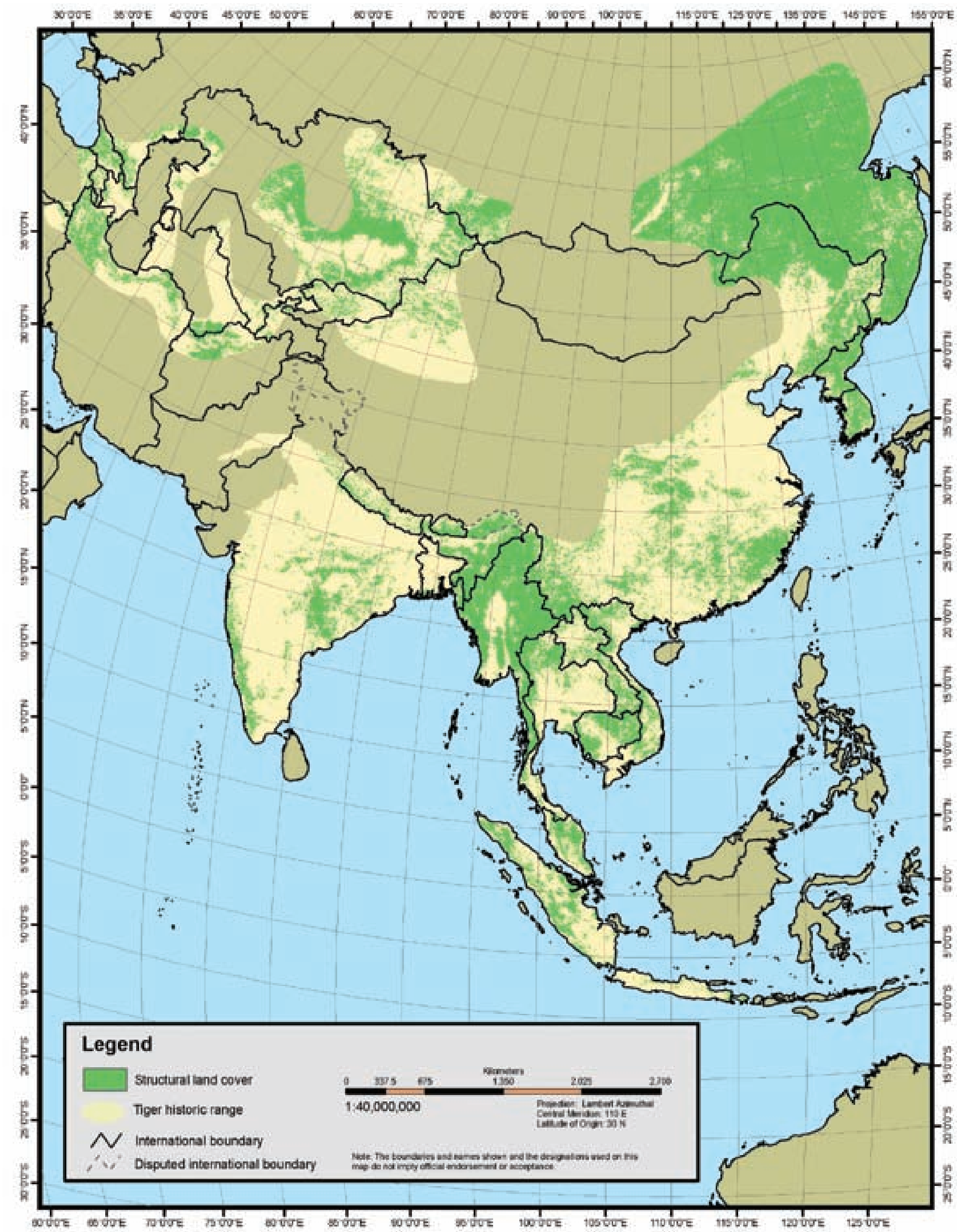

Figure 4.3 Structural land cover in the tiger historic range

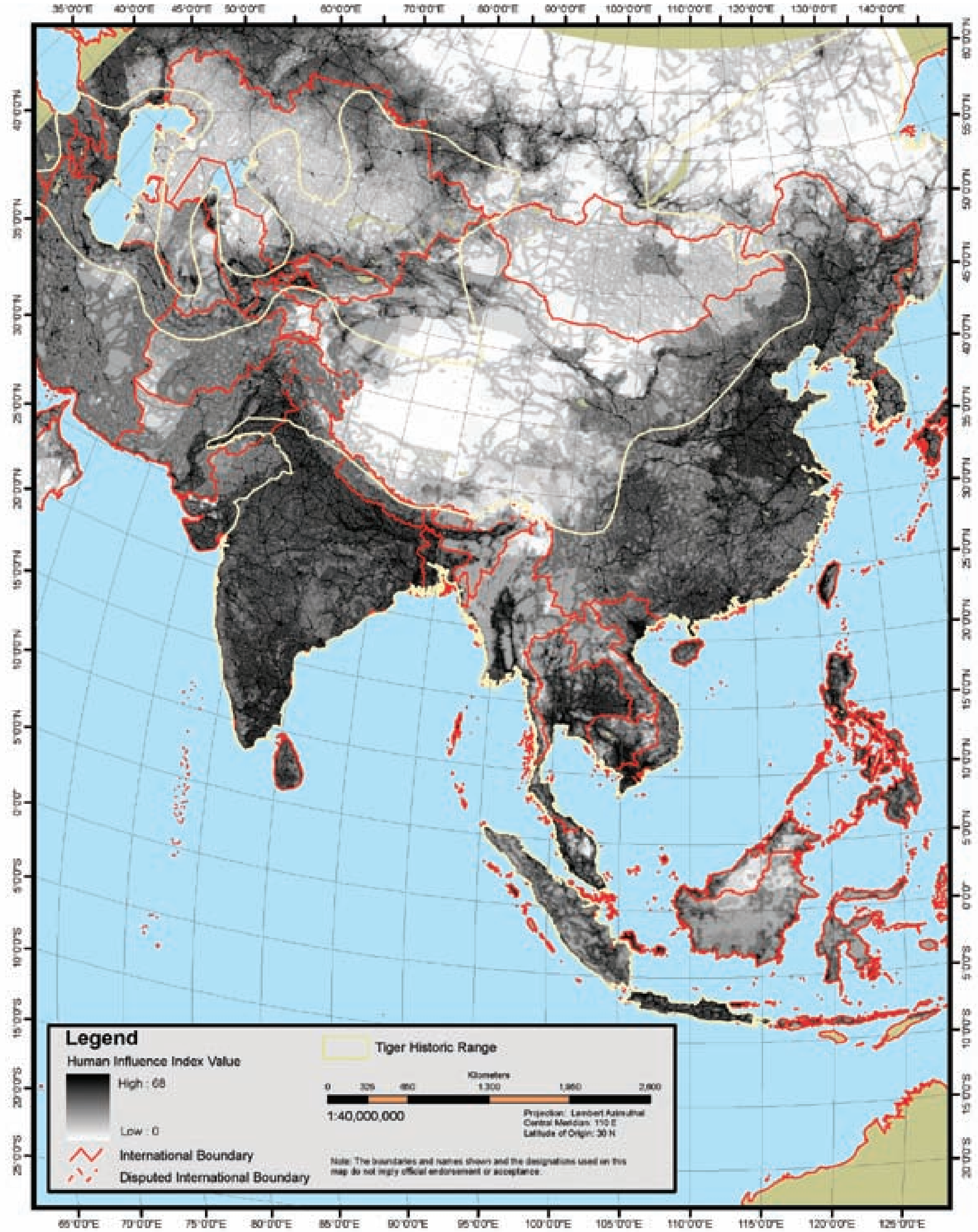

Figure 4.4 Human influence index in Asia

human influence within the tiger's current range. If tigers are present more often at a given human influence value than expected by random, there will be a positive, non-zero deviation from the overall human influence distribution; if tigers are found less often than expected by random, there will be a negative, non-zero deviation. Similarly, we analyzed the "putative absence" data. By examining the patterns of deviations from zero (Figure 4.5), it appears that there is a transition around Human Influence Index value 16. Below HII 16, it is more likely than would be expected to find tigers; at above HII 16, it is less likely than expected to find them, based on both analysis of tiger presence and absence data. All data are expressed as percentages so that they can be shown on the same scale, since the number of tiger presence points is much larger than tiger absences. We test the sensitivity of the model results to the selected HII threshold in Chapter 5.

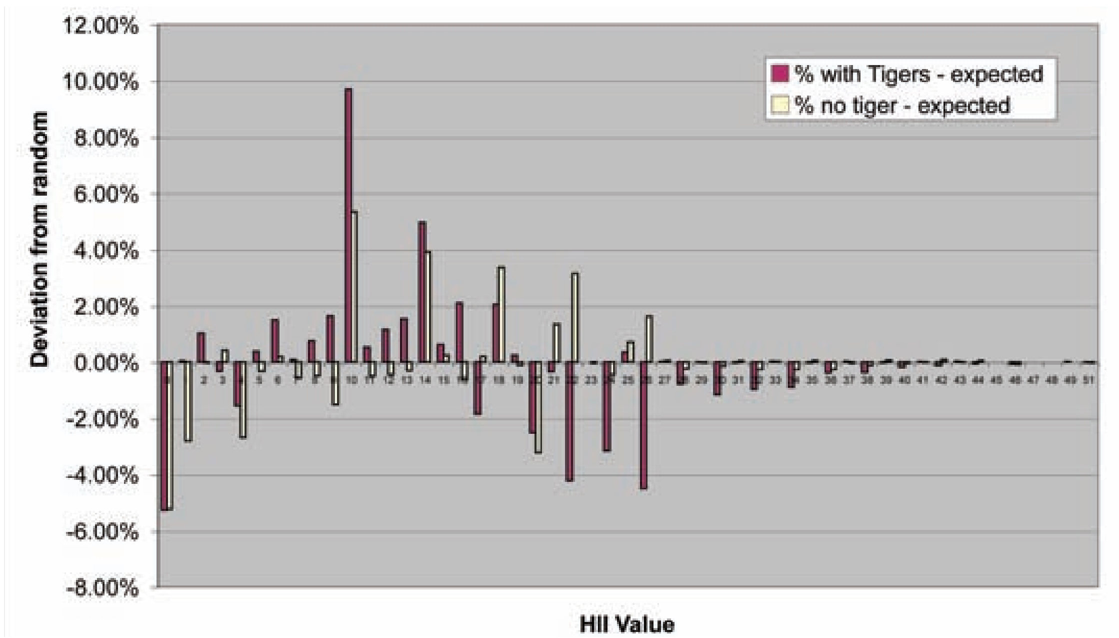

Figure 4.5 Distribution of tigers in relation to HII value

To create a map of "effective potential habitat" we excluded areas of structural land cover with HII scores higher than 15 (Figure 4.6). Note that there are instances of tiger presence at HII values greater than 15. If these areas are adjacent to tiger landscapes, as described in the next section, they are added back as areas available for tigers, regardless of their human influence score.

4.3.4 Minimum Habitat Size and Connectivity Analysis

The map of effective potential tiger habitat shows available habitat for tigers across the range. Tigers need generally large blocks of habitat and are not able to use small patches unless closely connected to larger areas. How much area a tiger requires depends on habitat-type and prey density, as studies over the last several years have shown (Carbone et al. 2001, Karanth and Stith 1999). What constitutes a connected area is less well known,

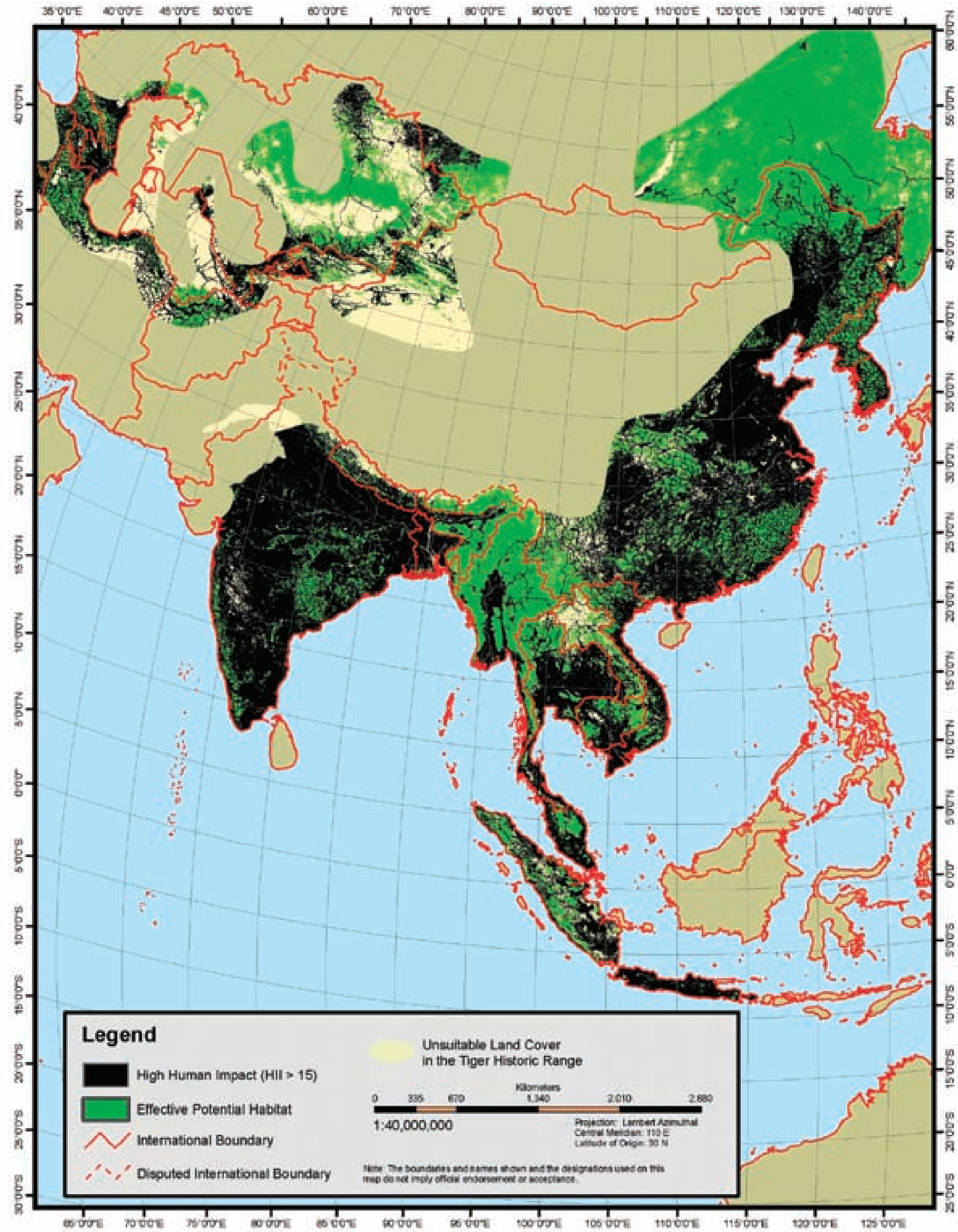

Figure 4.6 Effective potential habitat after human influence mask

so we use a conservative approach to map connectivity according to presumed dispersal capability of tigers.

We used the results of research on ecological tiger densities acquired since the TCU 1.0 to determine both minimum core area and stepping stone size requirements. Tiger density is contingent in part upon the type of habitat the tiger uses, so to reflect this we stratified our minimum size threshold by habitat-type. Habitat areas were represented by WWF ecoregions (Olson et al. 2001) that were grouped into "density regions" according to their characteristics for supporting similar densities of tigers. We defined a minimum size for a "core" habitat block for a TCL to be "big enough for five tigers" over one year old, which varies between 30 to 625 km^2 [4]. We set the minimum "stepping stone" habitat patch to be 10% of the "core" habitat block, with a range between 3 to 63 km^2. Table 4.3 shows grouped ecoregions and their associated tiger densities and minimum core area and stepping stone sizes, while Figure 4.7 shows the boundaries of the habitat-types.

#	Habitat-type	Ecoregions	Observed Density (tigers/100 km^2)	Minimum Core Patch Size (km^2)	Minimum "Stepping Stone" Size (km^2)	Original Source
1	Extirpated Range	Extirpated – part of China, Central Asia, Java, Bali, Pakistan	0	250	25	Mazak 1981, Nowell and Jackson 1996
2	Non-habitat	Northeast India-Myanmar pine forests, Sumatran tropical pine forests, Eastern Himalayan subalpine conifer forests, Western Himalayan subalpine conifer forests, Deccan thorn scrub forests, Northeastern Himalayan subalpine conifer forests, Eastern Himalayan alpine shrub and meadows, Western Himalayan alpine shrub and Meadows, Western Himalayan broadleaf forests	0	NA	NA	No reports
3	Temperate Broadleaf and Mixed Forests	Central Korean deciduous forests, Changbai Mountains mixed forests, Manchurian mixed forests, Northeast China Plain deciduous forests, Ussuri broadleaf and mixed forests	0.2 - 0.35	625	63	Smirnov and Miquelle 1999 (Sikhote-Alin Biosphere Reserve); Matyuskin et al 1996
4	Tropical and Subtropical Moist forests	Cardamom Mountains rain forests, Chao Phraya freshwater swamp forests, Chin Hills-Arakan Yoma montane forests, Himalayan subtropical broadleaf forests, Irrawaddy freshwater swamp forests, Kayah-Karen montane rain forests, Luang Prabang montane rain forests, Malabar Coast moist forests, Meghalaya subtropical forests, Mizoram-Manipur-Kachin rain forests, Myanmar coastal rain forests, North Western Ghats montane rain forests, Northern Annamites rain forests, Northern Indochina subtropical forests, Northern Triangle subtropical forests, Northern Vietnam lowland rain forests, Peninsular Malaysian montane rain forests, Peninsular Malaysian peat swamp forests, Peninsular Malaysian rain forests, Red River freshwater swamp forests, South China-Vietnam subtropical evergreen forests, South Western Ghats montane rain forests, Southern Annamites montane rain forests, Sumatran freshwater swamp forests, Sumatran lowland rain forests, Sumatran montane rain forests, Sumatran peat swamp forests, Sundarbans freshwater swamp forests, Tonle Sap freshwater swamp forests, Tonle Sap-Mekong peat swamp forests, Eastern Himalayan broadleaf forests	1.06 – 2.78	250	25	Kawanishi and Sunquist. 2004 (Taman Negara National Park); Linkie et al. in press, Linkie et al. 2004 (Kerenci Seblat); O'Brien et al. 2003 (Bukit Barisan, Way Kambas); Carbone et al. 2001 (Royal Chitwan National Park), McDougal and Tshering 1998 (Bhutan)

Table 4.3 Habitat-types and associated tiger densities.

[4] When more than one choice was available to us for tiger densities in a particular habitat type, we went with the lowest density to create a relatively lenient size filter and to refrain from excluding good landscapes from appropriate management.

To simulate habitat connectivity, we assigned all habitat and stepping stones within 4 km of one another and meeting the minimum size requirements for that habitat-type to a unique habitat group. In rare occasions where a wide river exceeding 1 km intersected a polygon (habitat patch group), the landscape was split into two distinct areas. The resulting habitat groups represent "proto-landscapes." A subsequent stage in the analysis will designate them as conservation, survey, or restoration landscapes.

4.3.5 Apply tiger data and assign area designations

The "proto-landscapes" created in the previous step represent general blocks of effective potential habitat that are large and connected enough to support a population of tigers. However, we have not yet established which areas have actually been surveyed and which areas actually have tigers.

Prior to assigning the tiger data, we segmented the proto-landscapes by ecoregion and country boundaries to improve the resolution of the analysis and to refine the assignment of survey results into more representative units. Each segment was overlaid with tiger

#	Habitat-type	Ecoregions	Observed Density (tigers/100 km^2)	Minimum Core Patch Size (km^2)	Minimum "Stepping Stone" Size (km^2)	Original Source
5	Tropical moist deciduous and semi-evergreen forests	Chao Phraya lowland moist deciduous forests, Irrawaddy moist deciduous forests, North Western Ghats moist deciduous forests, Northern Khorat Plateau moist deciduous forests, Northern Thailand-Laos moist deciduous forests, Orissa semi-evergreen forests, Tenasserim-South Thailand semi-evergreen rain forests	3.4	140	14	Karanth et al. 2004b (Bhadra Tiger Reserve)
6	Tropical dry forest	Central Deccan Plateau dry deciduous forests, Central Indochina dry forests, Chhota-Nagpur dry deciduous forests, East Deccan dry-evergreen forests, Irrawaddy dry forests, Narmada Valley dry deciduous forests, Northern dry deciduous forests, South Deccan Plateau dry deciduous forests, Southeastern Indochina dry evergreen forests, Southern Vietnam lowland dry forests, Himalayan subtropical pine forests	6.1 – 6.8	70	7	Karanth et al. 2004b (Pench and Melghat); Karanth et al. 2004a, Chundawat and van Gruisen 2004 (Panna)
7	Indian subcontinent moist deciduous forests	Eastern highlands moist deciduous forests, Lower Gangetic Plains moist deciduous forests, South Western Ghats moist deciduous forests, Upper Gangetic Plains moist deciduous forests	11.50-11.92	45	5	Karanth et al. 2004b (Kanha, Nagarahole, Ranthambhore)
8	Tropical and subtropical grasslands and forests	Terai Duar savanna and grasslands; Brahmaputra Valley semi-evergreen forests	15.84-16.76	30	3	Karanth et al. 2004b (Kazaranga); Carbone et al. 2001 (Royal Chitwan Natonal Park)
9	Mangroves	All mangrove ecoregions	1.4	250	25	Karanth and Nichols pers. comm. 2003 (Sundarbans Biosphere Tiger Reserve)

Table 4.3 (*continued*) Habitat-types and associated tiger densities.

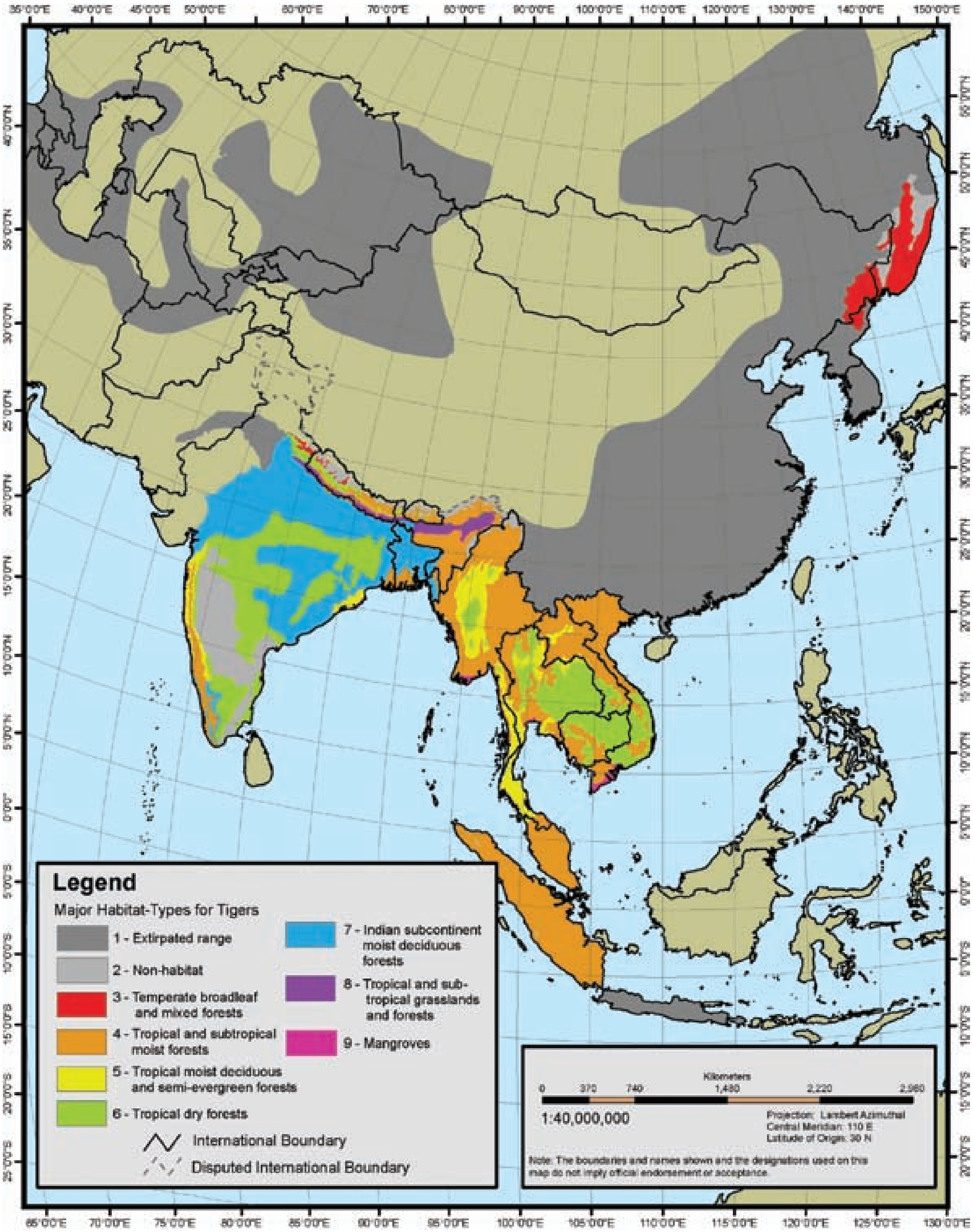

Figure 4.7 Major habitat-types

location data (Chapter 2) to assign one of three categories: tiger conservation areas, survey areas, and restoration areas.

- ***Tiger Conservation Areas*** Areas with tigers;
- ***Tiger Survey Areas*** Habitat areas in the current range that have not been surveyed in the past 10 years;
- ***Restoration Areas*** habitat areas in the current range that have been surveyed, with no tigers found.

We used the tiger conservation database (Chapter 2) composed of point and polygon data on tiger locations submitted to the project by experts, in addition to a number of records compiled from published and gray literature and reports on tiger locations (Figure 4.8). We selected for the analysis all locations from non-provisional sources. In cases where two sources yielded opposing results for a given geographic area, we selected the record with tiger presence over tiger absence. In some cases, we selected newer survey results over older information when the new source is believed to be reliable.

For the purposes of this analysis we assumed that a tiger identified at a given point location could be found at any location within a distance of 3 to 14 km, with the distance varied in proportion to tiger density (and estimated home range size) for a particular habitat-type. We call the area around a survey location over which the tiger is estimated to range the "area of tiger presence." We test the sensitivity of the analysis to this decision about area of tiger presence in Chapter 5.

4.3.6 Reassemble tiger landscapes

The result of the tiger data assignment are hundreds of areas, many too small to lend themselves to a range-wide prioritization plan, many of which are immediately adjacent to other areas, but divided by the ecoregion and country boundaries used previously. To reassemble the landscapes, all areas of a given status were merged with adjacent areas of the same status. Habitat fragments with tigers were merged into adjacent TCLs. In cases where survey and restoration landscapes adjacent to TCLs were too small on their own to support 5 tigers, we assigned these landscapes to the adjacent TCL with the longest boundary of adjacency.

4.3.7 Map restoration areas within the extirpated range

Similar methods were used to map restoration landscapes with the part of the range from which tigers have been extirpated. We applied the same habitat definitions based on the land cover maps and human influence index values. Because there is no tiger presence data from this part of the range, all delineated landscapes were marked for restoration. Tiger absence data were used to indicate whether tigers were extirpated from a landscape before or after 1985.

Figure 4.8 Tiger survey locations and results

4.3.8 Automation

The delineation methods described in sections 4.3.1 through 4.3.7 were automated using an ARC/INFO Arc Macro Language (AML) script (ESRI ArcGIS 8.3, Redlands, CA.) The original analysis, when conducted "by hand" during development, required over three weeks of work. The script now allows us to complete the process in approximately 20 minutes, following the preparation and standardization of input data layers. Automation of the process enables the analysis to be truly "living"—with every change in any of the inputs, a revised range-wide analysis can be produced efficiently.

4.3.9 Field review

The delineation results were reviewed from June to August 2005, after making the draft results available for download from a Web site and notifying our list of over 160 tiger experts. Over 35 tiger conservationists representing organizations from all 13 countries in the current tiger range responded. The responses helped us to update the TCD with over 1,600 survey locations, improve the land cover dataset, and modify the methodology used to delineate landscapes.

4.4 Results: Delineation of Tiger Landscapes

4.4.1 Status of tiger habitat across the range

Using the above set of methods, we identified 76 TCLs, 491 Survey Landscapes, 34 Restoration Landscapes, and 543 Small Fragments with Tigers in the current tiger range (Figures 4.9 – 4.10). In the extirpated range of China, central Asia, and Java, 427 restoration landscapes were delineated, 14 of which are believed to have been inhabited by tigers within the past 20 years (Figure 4.11).

TCLs effectively make up an area of 1,184,911 km^2, only about 7.1%, of the historical range of tigers. In effect, tigers have lost 92.9% of their range over the last 150 years.

Survey landscapes, where the status of tigers is unknown, make up 431,306 km^2, roughly 2.6% of historical range.

Within the current range, areas for restoration make up 326,954 km^2 (or roughly 2.0% of historical range); in the extirpated part of the range, restoration landscapes occupy a much larger area (4,520,467 km^2, or 27.2% of the historical range), although tigers are no longer present there. 513,522 km^2 of this has been lost to tigers for less than 20 years.

These estimates of tiger habitat lost and remaining are based on the overall landscape areas. Because of the connectivity rules these areas include some in which tigers can not live ("non-habitat"). The amount of non-habitat within a TCL can vary from 20 to 90% depending on the area; on average, the values is approximately 55%. In short, even with our more restrictive definitions of habitat used in this exercise, our TCLs still overestimate the amount of habitat actually available to tigers within a TCL.

4.4.2 Representation of tiger habitat across biomes and bioregions

TCLs are distributed across 10 different biomes, ranging from the boreal forests of Russia to tropical and subtropical grasslands and broadleaf forests in India and Southeast Asia. Of all the habitat types, TCLs are most overwhelmingly found in tropical moist broadleaf forests, followed by temperate broadleaf and mixed forests (mainly within the Russian Far East), followed by tropical dry forests. When total biome area is taken into consideration, however, we find that the biomes in which tigers are most commonly found are so highly impacted that only 8 to 15% of these biomes' area is actually incorporated in tiger landscapes (see Table 4.4). Some habitat types in the historic range that are less impacted by humans are, unfortunately, also less suitable for tigers. These include the boreal forests in Russia and coniferous forests in Southeast Asia, which have a fairly large percent of their area remaining that is still under low impact, but relatively little of which is actually occupied by tigers (as TCLs). This result suggests that humans and tigers compete for space in many of the same biomes, and that tigers are being pushed to the end of the remaining habitat types where they can actually live.

Biome	Total Biome Area (Km2)	Total Effective Potential Habitat (km2)	Total TCL Area (km2)	Potential Habitat as Percent of Biome Area	TCL Area as Percent of Biome Area
Tropical & Subtropical Moist Broadleaf Forests	4,743,919	1,768,196	700,991	37.27	14.78
Tropical & Subtropical Dry Broadleaf Forests	1,460,811	204,048	122,599	13.97	8.39
Tropical & Subtropical Coniferous Forests	55,647	24,214	4,855	43.51	8.72
Temperate Broadleaf & Mixed Forests	3,003,131	1,037,006	251,516	34.53	8.38
Temperate Conifer Forests	510,338	410,536	5,130	80.44	1.01
Boreal Forests/Taiga	1,760,128	1,703,572	72,208	96.79	4.10
Tropical & Subtropical Grasslands, Savannas & Shrublands	34,574	4,047	7,265	11.71	21.01
Temperate Grasslands, Savannas & Shrublands	1,566,240	888,301	0	56.72	0.00
Flooded Grasslands & Savannas	196,477	68,221	18,430	34.72	9.38
Montane Grasslands & Shrublands	402,384	332,522	1,525	82.64	0.38
Tundra	222,191	220,920	0	99.43	0.00
Mediterranean Forests, Woodlands & Scrub	1,271	37	0	2.91	0.00
Deserts & Xeric Shrublands	2,507,028	1,657,505	0	66.11	0.00
Mangroves	75,592	5,639	5,449	7.46	7.21

Table 4.4 Area of TCLs and habitat by biome *Note: All calculations are done for the entire historic range. TCL area is total area of landscape, including both habitat and non-habitat. Effective Potential Habitat is by definition structural land cover of low human influence. Percent potential habitat is the percent of the biome's total area that is occupied by effective potential habitat. TCL Area exceeds effective potential habitat area in Tropical and Subtropical Grasslands because non-habitat is included in TCLs in addition to habitat.*

Tigers also range across several different geographical regions, such as the Indian subcontinent, Indochina, mainland Southeast Asia, Sumatra, and the Russian and Chinese Far East. When geographic regions are compared according to the total amount of remaining effective potential habitat, we find that the largest area of such habitat remains in the

Russian Far East, consisting of over 2 million km^2. This represents more than 86% of the total area of the tiger historic range in that region. The smallest amount of remaining effective potential habitat as a percentage of total habitat is in the Indian Subcontinent, where all but 300,000 km^2, or 11% of total habitat has been eliminated for tigers. This is even less than habitat area remaining in parts of the extirpated range. In fact, about 25% of the now extirpated geographic regions of China and central Asia have structural land cover that is not under high impact from human infrastructure and population density (see Table 4.5), suggesting that lack of human infrastructure and population with structural land cover are not the only factors necessary to sustain tigers.

Geographic Region	Effective Potential Habitat (km^2)	Total Area of Geographic Region (km^2)	Percent Habitat Remaining (%)
Bali and Java	3,068	131,363	2.3
Central Asia	1,054,607	4,157,327	25.4
China-Korea	1,076,369	4,311,950	25.0
Indian Subcontinent	327,061	2,969,805	11.0
Indochina	820,486	1,990,858	41.2
Peninsular Malaysia	30,228	129,939	23.3
Russian Far East	2,242,965	2,585,544	86.8
Sumatra	95,280	430,251	22.1

Table 4.5 Area of habitat by geographic region *Note: Effective Potential Habitat is structural landcover of low human influence. Percent potential habitat is the percent of the biome's total area that is occupied by effective potential habitat.*

When further broken down by ecogeographic unit (combinations of biome and geographic unit), the largest amount of tiger habitat appears to remain in Indochina tropical broadleaf forests, followed by Russian temperate broadleaf and mixed forests. The largest number of TCLs are found in tropical broadleaf forest of the Indian subcontinent, indicating the remnants of a once favored but now highly fragmented part of the tiger range. The ecogeographic unit with the largest remaining area of potential habitat is Russian boreal forest—however, much of this part of the range has been extirpated. The second most important area of remaining potential habitat not limited to known tiger habitat is Indochina tropical broadleaf forest. Results confirm that there is no remaining tiger habitat in central Asia, Bali and Java, and China, although large areas of effective potential habitat remain, particularly in central Asia and China (Table 4.6).

4.4.3 Characteristics of TCLs

TCLs were also analyzed according to their individual characteristics such as habitat and country representation and size (see Table 4.7). When they were compared for their biome representation, we find that 41 TCLs out of 76 have more than one biome, and 10 have 3 or more biomes represented. Thus, protecting tigers in certain TCLs will also have an effect of preserving habitat diversity where they live.

BIOME	# TCLs	TCL Area (km²)	# RLs	RL Area (km²)	# SLs	SL Area (km²)	# RLEs	RLE Area (km²)	Structural land cover (km²)	Effective Potential Habitat (km²)	Total Area of Ecogeographic Unit (km²)
Bali and Java											
Tropical & Subtropical Moist Broadleaf Forests	0	0	0	0	0	0	1	576	14,414	3,068	131,363
Central Asia											
Temperate Broadleaf & Mixed Forests	0	0	0	0	0	0	53	85,121	150,914	80,998	333,211
Temperate Conifer Forests	0	0	0	0	0	0	31	96,149	103,047	84,684	170,766
Temperate Grasslands, Savannas & Shrublands	0	0	0	0	0	0	94	311,434	376,496	283,616	1,208,698
Montane Grasslands & Shrublands	0	0	0	0	0	0	43	126,866	119,166	99,887	362,825
Mediterranean Forests, Woodlands & Scrub	0	0	0	0	0	0	0	0	0	0	1,271
Deserts & Xeric Shrublands	0	0	0	0	0	0	61	566,169	568,875	505,191	2,038,391
China-Korea											
Tropical & Subtropical Moist Broadleaf Forests	0	0	3	119	4	17	110	390,371	519,991	343,306	1,476,044
Tropical & Subtropical Dry Broadleaf Forests	0	0	0	0	0	0	0	0	0	0	26
Temperate Broadleaf & Mixed Forests	1	25,116	0	0	6	20,131	128	412,332	710,280	435,024	2,279,566
Temperate Conifer Forests	0	0	1	1	2	8	14	146,568	153,641	128,155	187,855
Boreal Forests/Taiga	0	0	0	0	0	0	4	8,293	7,563	7,469	8,476
Temperate Grasslands, Savannas & Shrublands	0	0	0	0	0	0	11	157,446	166,155	146,694	245,786
Flooded Grasslands & Savannas	2	7,603	0	0	1	539	10	7,454	39,238	15,702	113,661
Montane Grasslands & Shrublands	0	0	0	0	0	0	2	8	17	17	200
Deserts & Xeric Shrublands	0	0	0	0	0	0	0	0	0	0	5
Mangroves	0	0	0	0	4	3	0	0	41	2	331
Indian Subcontinent											
Tropical & Subtropical Moist Broadleaf Forests	29	122,626	6	3,909	250	135,790	0	0	306,906	171,846	1,187,559
Tropical & Subtropical Dry Broadleaf Forests	15	29,676	8	9,273	169	50,888	0	0	110,592	59,332	946,679
Tropical & Subtropical Coniferous Forests	4	3,985	1	0	29	5,792	0	0	14,722	7,138	42,925
Temperate Broadleaf & Mixed Forests	1	60,991	2	13	27	7,220	0	0	69,953	62,480	94,928
Temperate Conifer Forests	1	4,891	1	3	20	15,047	0	0	18,655	16,039	40,056
Tropical & Subtropical Grasslands, Savannas & Shrublands	6	7,197	1	528	18	788	0	0	9,933	2,976	34,574
Montane Grasslands & Shrublands	1	55	1	0	12	6,019	0	0	4,345	4,121	33,002
Deserts & Xeric Shrublands	0	0	1	192	3	458	0	0	5,800	1,834	561,458
Mangroves	1	5,265	0	0	0	0	0	0	6,063	1,246	22,909

Table 4.6 Tiger landscapes and habitat summarized by ecogeographic unit

Just as tiger habitat appears to cross different habitat types, we find that tiger habitat does not pay heed to political boundaries. Fifteen TCLs cross at least one set of country boundaries, and 3 TCLs are found in at least 3 countries. Transboundary TCLs are found in all countries in the current tiger range except for Indonesia. Because transboundary issues affect a large percentage of TCLs and almost all countries in the tiger range, it is apparent that overcoming management challenges posed by this set of TCLs will be critical to the long-term survival of tigers.

Three different indicators of TCL size were analyzed: total landscape area, effective potential habitat area, and relative area. We see that within landscapes, actual habitat area

BIOME	# TCLs	TCL Area (km^2)	# RLs	RL Area (km^2)	# SLs	SL Area (km^2)	# RLEs	RLE Area (km^2)	Structural land cover (km^2)	Effective Potential Habitat (km^2)	Total Area of Ecogeographic Unit (km^2)
Indochina											
Tropical & Subtropical Moist Broadleaf Forests	15	436,544	17	295,104	75	104,581	0	0	858,804	700,401	1,400,305
Tropical & Subtropical Dry Broadleaf Forests	11	92,070	18	15,233	68	31,475	0	0	177,499	96,018	514,105
Tropical & Subtropical Coniferous Forests	0	0	1	57	3	9,544	0	0	9,243	8,781	9,705
Temperate Broadleaf & Mixed Forests	1	10,308	2	19	2	0	0	0	9,512	9,378	10,706
Temperate Conifer Forests	0	0	1	1,729	3	2,397	0	0	2,823	2,812	6,955
Montane Grasslands & Shrublands	1	1,332	1	753	1	1	0	0	1,065	1,034	6,357
Mangroves	0	0	0	0	2	2,306	0	0	11,133	2,062	42,725
Peninsular Malaysia											
Tropical & Subtropical Moist Broadleaf Forests	3	55,514	0	0	1	11	0	0	63,754	30,228	129,519
Mangroves	0	0	0	0	0	0	0	0	351	0	420
Russian Far East											
Temperate Broadleaf & Mixed Forests	1	156,272	0	0	0	0	9	107,830	253,854	233,077	284,720
Temperate Conifer Forests	0	0	0	0	0	0	2	101,045	102,446	97,769	104,707
Boreal Forests/Taiga	1	72,207	0	0	0	0	12	1,635,840	1,611,842	1,580,208	1,751,653
Temperate Grasslands, Savannas & Shrublands	0	0	0	0	0	0	1	105,991	99,492	90,585	111,756
Flooded Grasslands & Savannas	1	9,973	0	0	0	0	3	42,920	62,321	43,182	82,817
Tundra	0	0	0	0	0	0	5	216,397	197,166	196,598	222,191
Sumatra											
Tropical & Subtropical Moist Broadleaf Forests	12	87,611	0	0	22	36,460	0	0	148,937	92,816	418,285
Tropical & Subtropical Coniferous Forests	1	729	0	0	3	1,229	0	0	2,093	1,860	2,760
Mangroves	0	0	0	0	4	410	0	0	3,074	604	9,206

Table 4.6 (*continued*) Tiger landscapes and habitat summarized by ecogeographic unit *Notes: TCL Tiger Conservation Landscape, RL Restoration Landscape in the current range, RLE Restoration Landscape in the extirpated portion of the tiger's range, SL Survey Landscape, Structural land cover is >= 5 km^2, Effective Potential Habitat: Structural land cover of low human impact. The sum of the number of TCLs, SLs, RLs, and RLEs in each ecogeographic unit exceed the total number of these landscapes rangewide because landscapes are counted for each habitat type that they overlap.*

is usually only about 55% of total landscape area (according to its mean and median) but ranges from 20% to 90% of the total landscape area. TCL sizes cover a large range, from 269,983 km^2 in the Russian Far East to 278 km^2 in India. Not surprisingly, the size of TCLs is skewed to the smaller end, with 61 of 76 TCLs below 10,000 km^2 and with a median size of only 2,904 km^2 for the entire set. Perhaps more important than actual TCL size is Relative Area, which is habitat area adjusted for the area necessary to support a minimum population, depending on the productivity of the habitat-type where the TCL is located (specifically, relative area=habitat area/core area minimum). When relative areas are compared, we find that TCLs range in size from 1 to 7,100 times their minimum size requirement, with the median relative area of 16, or enough area to support roughly 16 times the minimum population of tigers. It should be noted that a "minimum tiger population" is considered to be only five animals, and not to be confused with a minimum viable population.

TCL Number	TCL Name	Number of Biomes	Number of Countries	Total TCL Area (km²)	Habitat Area (km²)	Area of Largest Habitat Patch	Relative Area	Habitat as % of Landscape Area
1	Heilongjiang	2	1	1,315	703	660	3	53.46
2	Russian Far East - China	3	2	269,983	216,578	183,237	866	80.22
3	Bukit Barisan Selatan South	1	1	2,107	1,115	962	4	52.92
4	Bukit Balai Rejang - Selatan	1	1	3,884	2,670	2,665	11	68.74
5	Kerinci Seblat	2	1	28,162	19,653	10,928	79	69.79
6	Bukit Rimbang Baling	1	1	4,395	2,298	1,563	9	52.29
7	Bukit Tigapuluh Landscape	1	1	7,106	5,417	5,213	22	76.23
8	Tesso Nilo Landscape	1	1	2,332	1,121	525	4	48.07
9	Kuala Kampar-Kerumutan	2	1	9,835	4,895	2,447	20	49.77
10	Berbak	2	1	2,543	1,604	1,286	6	63.08
11	Rimbo Panti-Batang Gadis East	1	1	2,890	1,713	1,116	7	59.27
12	Rimbo Panti-Batang Gadis West	1	1	1,486	889	843	4	59.83
13	Sibologa	1	1	1,292	856	654	3	66.25
14	Leuser Ecosystem	2	1	22,319	16,000	7,817	64	71.69
15	Endau Rompin	1	1	6,505	1,552	629	6	23.86
16	Taman Negara - Belum	2	2	49,181	26,727	12,908	191	54.34
17	Krau	1	1	1,248	471	469	2	37.74
18	Khlong Saeng	2	1	4,816	1,828	1,545	13	37.96
19	Tenasserims	3	2	162,726	128,238	113,993	1,832	78.81
20	Salak-Phra	1	1	647	383	379	2	59.2
21	Phu Miang - Phu Thong	2	2	16,273	13,254	12,934	189	81.45
22	Phu Khieo	2	1	5,760	3,637	2,315	52	63.14
23	Khao Yai	2	1	2,253	1,717	1,668	25	76.21
24	Thap Lan - Pang Sida	1	1	4,445	3,027	2,778	43	68.1
25	Cardamoms	3	2	26,345	14,883	11,470	213	56.49
26	Cambodian Northern Plains	1	3	26,835	16,188	8,526	231	60.32
27	Southern-Central Annamites	2	3	61,252	37,521	30,063	536	61.26
28	Cat Tien	2	1	3,359	2,579	2,567	37	76.78
29	Bi Dup-Nui Ba	2	1	1,660	798	792	11	48.07
30	Kon Ka Kinh	2	1	6,389	1,274	796	18	19.94
31	Chu Mom Ray	1	1	1,787	993	885	14	55.57
32	Xe Bang Nouan	1	1	657	436	427	6	66.36
33	Hin Nam Ho	1	1	2,727	1,718	1,236	7	63
34	Northern-Central Annamites	1	2	28,826	19,160	11,191	137	66.47
35	Nam Et Phou Loey	1	2	17,866	11,961	6,958	85	66.95
36	Nam Ha	1	1	3,217	1,767	1,268	7	54.93
37	Northern Forest Complex - Namdapha - Royal Manas	6	3	237,820	213,018	196,851	7,101	89.57

Table 4.7 Characteristics of individual TCLs

TCL Number	TCL Name	Number of Biomes	Number of Countries	Total TCL Area (km^2)	Habitat Area (km^2)	Area of Largest Habitat Patch	Relative Area	Habitat as % of Landscape
38	Kaziranga - Garampani	1	1	7,514	5,609	4,648	187	74.65
39	Sundarbans	1	2	5,304	1,196	334	5	22.55
40	Royal Chitwan	3	2	4,055	1,257	560	42	31
41	Royal Bardia South	3	1	499	206	83	7	41.28
42	Royal Bardia	3	2	6,777	3,272	740	109	48.28
43	Royal Suklaphanta	3	2	1,144	467	300	16	40.82
44	Corbett - Sonanadi	3	2	5,996	1,758	251	59	29.32
45	Rajaji	2	1	1,044	301	172	7	28.83
46	Yamuna	3	1	322	120	82	3	37.27
47	Panna East	2	1	1,390	613	178	14	44.1
48	Panna West	1	1	539	171	103	2	31.73
49	Bandhavgarh - Panpatha	2	1	2,020	905	249	20	44.8
50	Kanha - Phen	2	1	10,598	5,605	690	125	52.89
51	Pachmarhi - Satpura - Bori	2	1	4,924	2,403	299	53	48.8
52	Melghat	1	1	2,398	1,277	503	18	53.25
53	Pench	2	1	2,918	1,280	205	28	43.87
54	Andhari - Tadoba	2	1	3,680	1,455	331	32	39.54
55	Indravati	2	1	44,238	24,775	1,576	551	56
56	Sunabeda-Udanti	2	1	2,287	1,445	603	32	63.18
57	Satkosia-Gorge	1	1	2,699	1,513	643	34	56.06
58	Simlipal	2	1	2,412	1,391	739	31	57.67
59	Palamau	2	1	3,209	1,859	727	41	57.93
60	Painganga	1	1	442	162	148	2	36.65
61	Nagarjunasagar South	1	1	1,699	832	337	12	48.97
62	Nagarjunasagar North	1	1	915	406	217	6	44.37
63	Shendurney	1	1	603	336	257	7	55.72
64	Periyar - Megamala	2	1	5,978	3,667	1,567	81	61.34
65	Anamalai-Parambikulam	1	1	3,071	1,611	831	36	52.46
66	Western Ghats - Bandipur - Khudrenukh - Bhadra	2	1	18,973	8,679	831	193	45.74
67	Biligiri Range	2	1	278	136	136	3	48.92
68	Valley	1	1	321	188	188	1	58.57
69	Dandeli South - Anshi	1	1	2,316	1,265	411	9	54.62
70	Dandeli North	1	1	517	291	177	2	56.29
71	Radhanagari	2	1	2,945	1,669	708	24	56.67
72	Chandoli	1	1	1,682	915	433	7	54.4
73	South	1	1	344	177	177	1	51.45
74	Purna	1	1	1,002	560	560	4	55.89
75	North	2	1	406	250	249	6	61.58
76	Shoolpaneswar	2	1	511	259	180	6	50.68

Table 4.7 (*continued*) Characteristics of individual TCLs *Notes: Total landscape area is the total area of the TCL, including both habitat and non-habitat. Habitat area is structural land cover for tigers with low human impact. Area of largest habitat patch is the area of the core habitat patch within the landscape. Relative area scales the size of the TCL to the habitat-type in which it is found. One unit of Relative Area represents enough habitat for approximately five tigers.*

4.5 Discussion: Interpretation of TCL Delineation

4.5.1 Advances in version 2.0

The delineation of tiger conservation landscapes, and associated areas, includes several advances in the science of range-wide priority-setting and has implications for tiger conservation across the species range. The results are the most current, objective assessment of tiger status and distribution available to date. They build from newly revised datasets on tiger distribution (Chapter 2) and land cover (Chapter 3), and they combine these datasets with others to produce a systematically derived map of tiger habitat distribution and occupancy. The results arise from a hierarchical methodology that begins with the tiger's historical range, then peels away areas of non-habitat, those with human influence exceeding that which is tolerated by tigers, and then removes areas where tiger survey data are negative or lacking. Each part of the range is clearly labeled in terms of its potential contribution to tiger conservation. Results are presented in a representative framework, including the major biome and regional distinctions across the range.

An important advance that builds on the last decade of field research on tigers are the habitat specific densities that are used to designate variably sized areas of sufficient habitat in different parts of the range. Habitat-specific thresholds are provided for minimum core areas and stepping-stones.

Another key advance that has not previously been used in species-level rangeiwide priority setting exercises is the incorporation of the human influence thresholds to represent "too much" human pressure on areas of apparent structural habitat. The use of the Human Fsootprint analysis (Sanderson et al. 2002) in this way represents a potential solution to the "empty forest" problem highlighted over 10 years ago (Redford 1992). This solution is portable to other species mapping problems and may yield insights into the distributions of different species.

Importantly, this process is automated and therefore immediately repeatable with each update to the input data sets. Automating the process creates the potential for a truly "living document." As new data comes in from field surveys, as the land cover dataset is updated, as our understanding of human-tiger conflict improves, our range-wide results can be updated. Automation also enables sensitivity analysis of parameter decisions, improving our understanding of model performance, as described in Chapter 5.

4.5.2 Data limitations and model complication

All models suffer from the qualities of the input datasets. Complicated models also suffer from the number of model relationships that need to be described and the parameter choices that need to be made. Every decision point provides an opportunity for error and uncertainty to enter the process. These delineation results, while the best that we can supply at this juncture, are affected by both data deficiencies and complication.

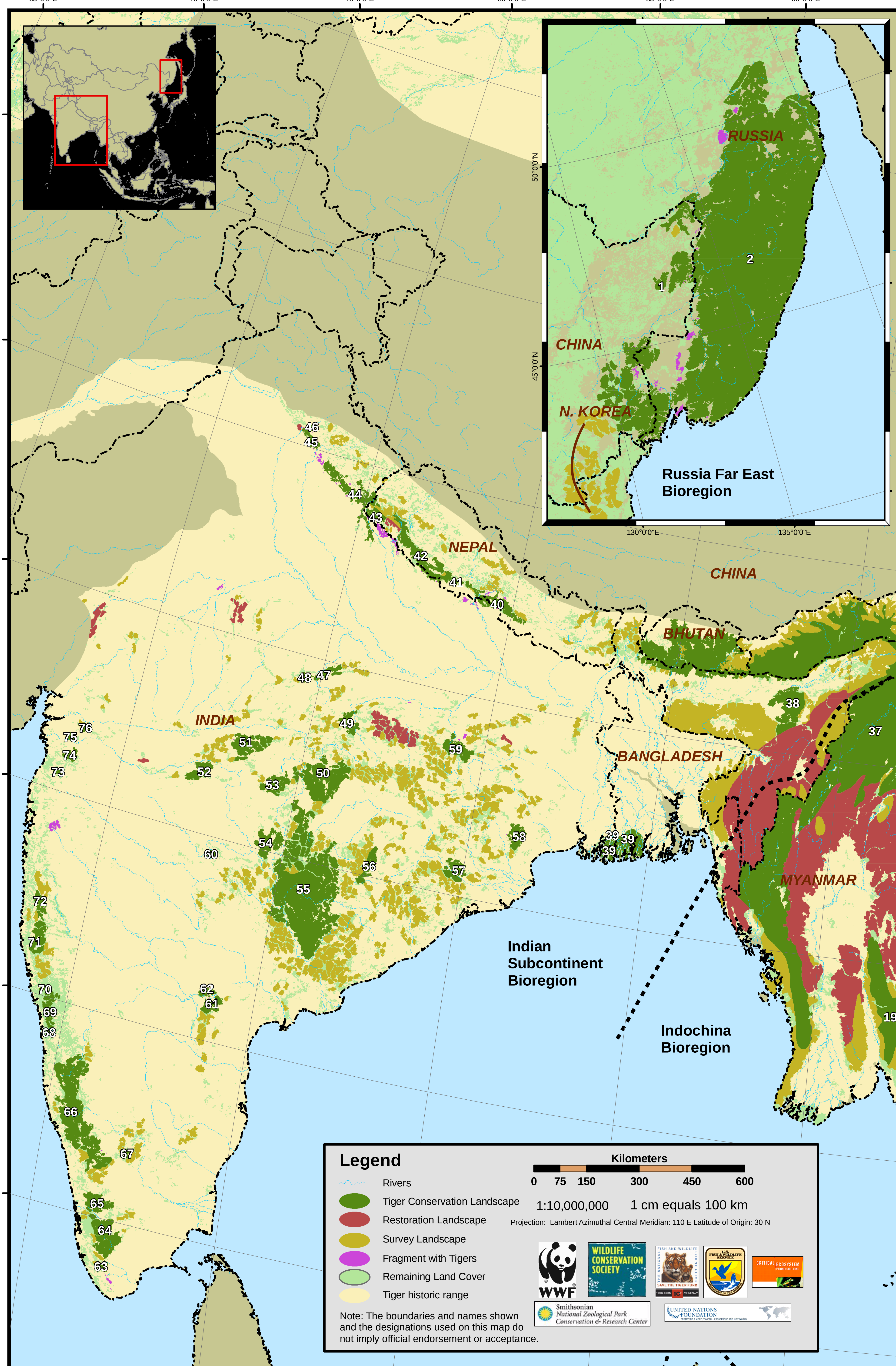

Figure 4.9 Tiger landscape delineation (Indian subcontinent, China and Russia)

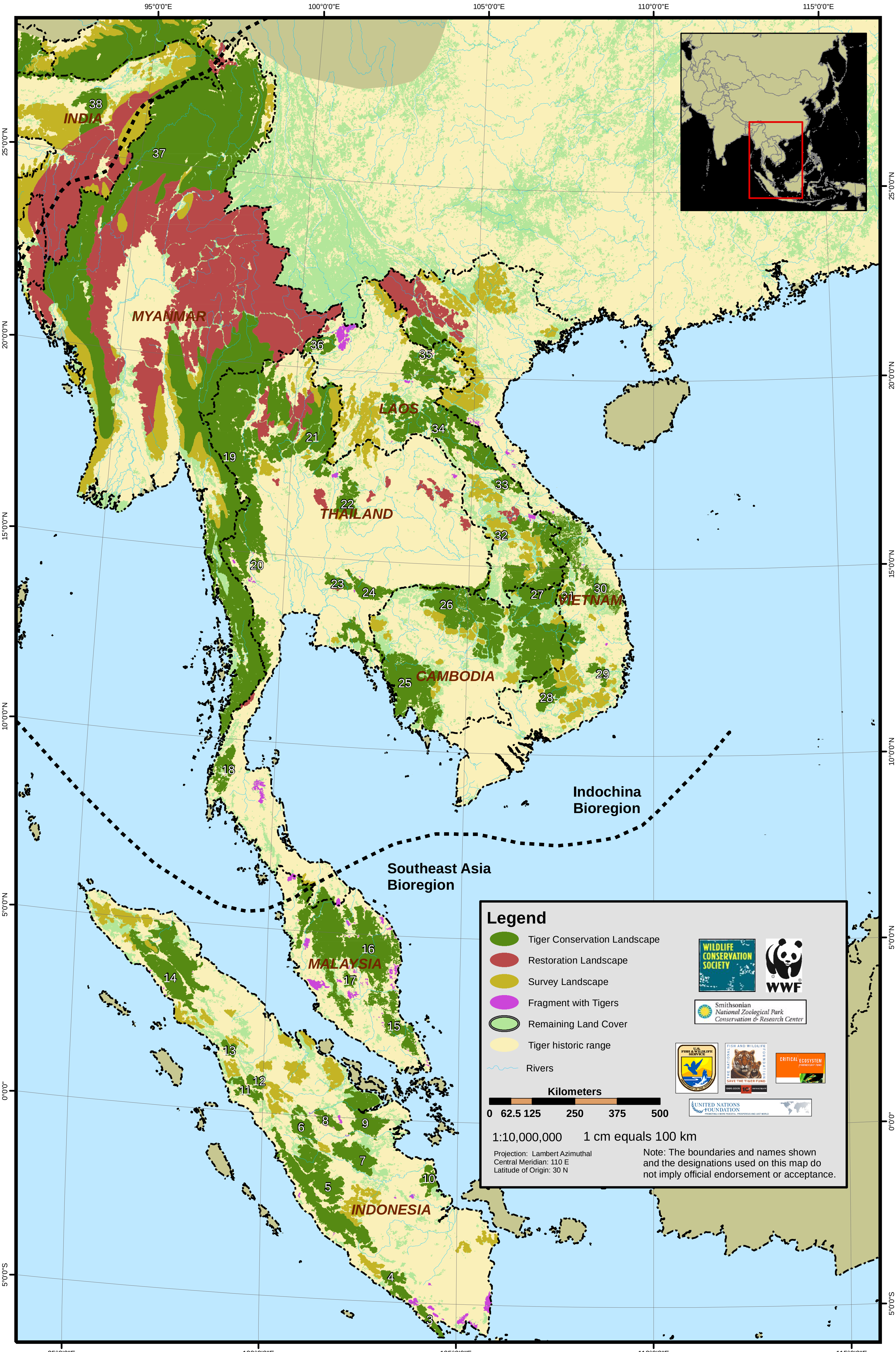

Figure 4.10 Tiger landscape delineation (Mainland Southeast Asia and Sumatra)

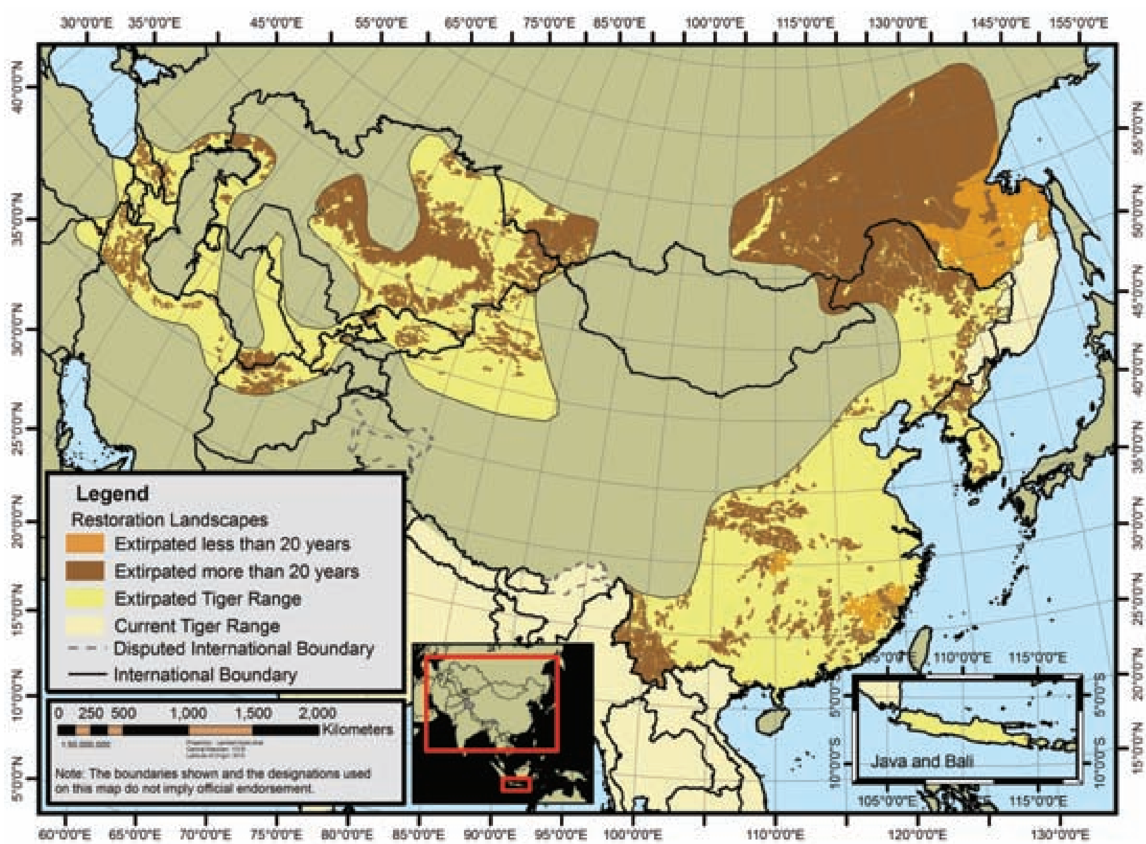

Fig 4.11 Restoration landscapes in the extirpated range

For these delineation results, it seems that the most important problem is with the land cover dataset. As discussed in Chapter 3, satellite based land cover assessments for the tiger's complete range have multiple problems, including confusing natural forest and plantations, resolution issues, and complications arising from combining multiple datasets, derived with different methods and for different purposes, into a unified dataset. A common complaint during the field review of the delineation results was that our land cover dataset was inadequate, either underestimating forest cover (as in central Sumatra and southern India in the Neyyara-Peppara protected area complex) or overestimating forest cover (as seen in the Western Ghats). In some cases, reviewers were able to provide higher resolution forest cover maps for their regions, however because of funding constraints, we were unable to digitize and patch in corrections for many areas. What is needed is a thorough mapping of forest cover across the tiger's range, using standardized methods and optimized for conservation purposes.

The tiger location database, while an important advance over previous efforts, is still incomplete for some regions and generally not as rich, extensive, and reliable as we would like. Tiger researchers use many different methods for confirming or denying the presence of tigers. There is great variation in the search effort used in different areas, and for many areas, we have no information at all. Since our definition of tiger landscapes explicitly incorporates consideration of tiger survey results, omissions from the results can strongly affect the results. Since we lacked scientific survey results for many parts of the range, and often lacked adequate information to make an informed judgment about the reliability of tiger reports in a given area, were often forced to use the default decision of assigning a landscape with tiger information if any report was received.

A related issue is how to deal with large, connected habitats with only a few tiger observations. According to the current model rules, a positive tiger observation connotes tiger presence in a block of connected habitat up to the nearest set of ecoregional or country boundaries. This rule is somewhat arbitrary, but it provides a mechanism for segmenting vast connected forest blocks (for example in Myanmar and connected areas in India, Thailand, and Laos) with only scattered tiger observations. Unfortunately, the habitat and country boundaries used still not do justice to actual variation in tiger distribution within a given habitat block. This has caused problems of analysis and interpretation in forested areas of Myanmar, Thailand, and Cambodia, in particular, where information on tiger distribution (and knowledge of other factors affecting tigers more generally) varies from one area of the habitat block to another.

It is important to note that the scale and grain of this analysis affects the interpretation of the results. When we began the project, we made choices about the type of data and methods to use that would be most appropriate to fulfilling its objectives, which was to map tiger habitat across the entire range and to objectively compare these habitats for investment purposes. We therefore selected regional scale datasets, and adopted a set of management definitions and decision rules that could be applied across the range. Although this set of methods was appropriate at the regional scale, a level of detail at the local scale was sacrificed. To help clarify local priorities not expressed in the regional-scale maps, national scale assessments using higher resolution datasets and methodologies fine-tuned to the local cultural and habitat characteristics would help to clarify local priorities for conservation effort. One example of a finer-scale analysis of tiger status at a national level is a recent assessment undertaken by a broad consortium of government agencies and non-governmental groups in Cambodia (see Appendix 6). The data used for these analyses will be made available to any party or group wishing to make a finer-scale, sub-regional or national analysis.

Local level assessments such as this might also stress the importance of areas with tigers that may be too small to be a regional investment priority, but are nonetheless locally important for their benefits to environmental education and ecotourism income, in addition to their obvious benefit of continuing to harbor small populations of tigers and their prey. In Sumatra, Way Kambas National Park, as well as a currently unprotected mosaic of plantation and lowland forest habitat in Jambi province, might fall into this category of places.

Uncertainty also surrounds several of our parameter choices. In comparison to 1997, our knowledge of tiger biology has improved, but is still far from perfect. We lack good data on tiger dispersal across different land cover types, designation of minimum core areas for tigers in all habitat-types, and the response of tigers to gross human influence measures, like the human footprint. Sensitivity analysis (Chapter 5) partly informs these choices, at least to the extent that we can know how the model will respond to a given change. For model choices with sensitivity, however, only more data and study will yield the necessary information.

4.5.3 Comparison of TCL 2.0 vs TCU 1.0

The tiger landscape revealed in this new assessment is very different from the initial assessment completed 10 years ago. Rather than 160 TCUs and survey areas in three bioregions (the Indian subcontinent, Indochina, and Southeast Asia, encompassing a total area of 1,636,201 km^2 found in TCU 1.0), we see a decrease in both the number and total area of TCLs. This is despite the fact that the new assessment has been done over a much larger expanse that includes the Russian Far East and Northern China, in addition to the bioregions initially assessed. The drop in the number of management units from 160 to 76 and an increase in the size of TCLs may at first glance appear to be reflective of a restoration of connectivity between tiger habitat across the range; however, it is more likely a reflection of a change in definitions between the 1995 and 2005 delineations. For example, accounting for dispersal capabilities between habitat patches in 2005 might have the effect of connecting previously separate TCUs. Incorporating a minimum size threshold in the new delineation may exclude habitats with tigers that were formerly included in the previous version.

A second surprising result is the drastic decrease in the total area occupied by TCLs. Even when we select TCLs in the portion of the range assessed in TCU 1.0, we see that current estimates of area occupied by tigers is an astounding 41% less than the 1995 estimate[5], revealing a far more critical scenario for tigers and tiger habitat than was revealed by the initial assessment. This difference between TCU 1.0 and TCL 2.0 may be attributed to an improved understanding of where tigers live as a result of field studies; improved rangewide datasets on land cover and human impact; higher resolution of the analysis; a revised methodology; and from habitat loss in some parts of the range. Since the current assessment stems from knowledge gained during and since the first assessment, we suggest that the current delineation presents an improvement upon the first version for estimating area occupied by tigers.

We see that different geographical areas of the range have been changed in different ways from TCU 1.0 to TCL 2.0. We see the sharpest decrease in area occupied by tigers in India, where we find landscapes with tigers to be far smaller and more fragmented than the original assessment revealed. In Southeast Asia, the TCLs of the new assessment resemble the shape of the old TCUs better than in India, although they tend to look smaller than in

[5]For this comparison, total TCL area in south and Southeast Asia (913.613 km^2) was compared with TCUs 1-3 with survey areas where later surveys revealed evidence of tigers (1,550,126 km^2).

TCU 1.0. In some areas of the range, there is no new TCL to replace an old TCU, suggesting that there is inadequate habitat or lack of tigers (or information on tigers) for the area to achieve TCL status. In other places such as parts of Sumatra, northern Myanmar, and central India, tigers have been found in areas originally designated for survey thus according them TCL status. For a visual comparison of TCL 2.0 to TCU 1.0, see Figure 4.12.

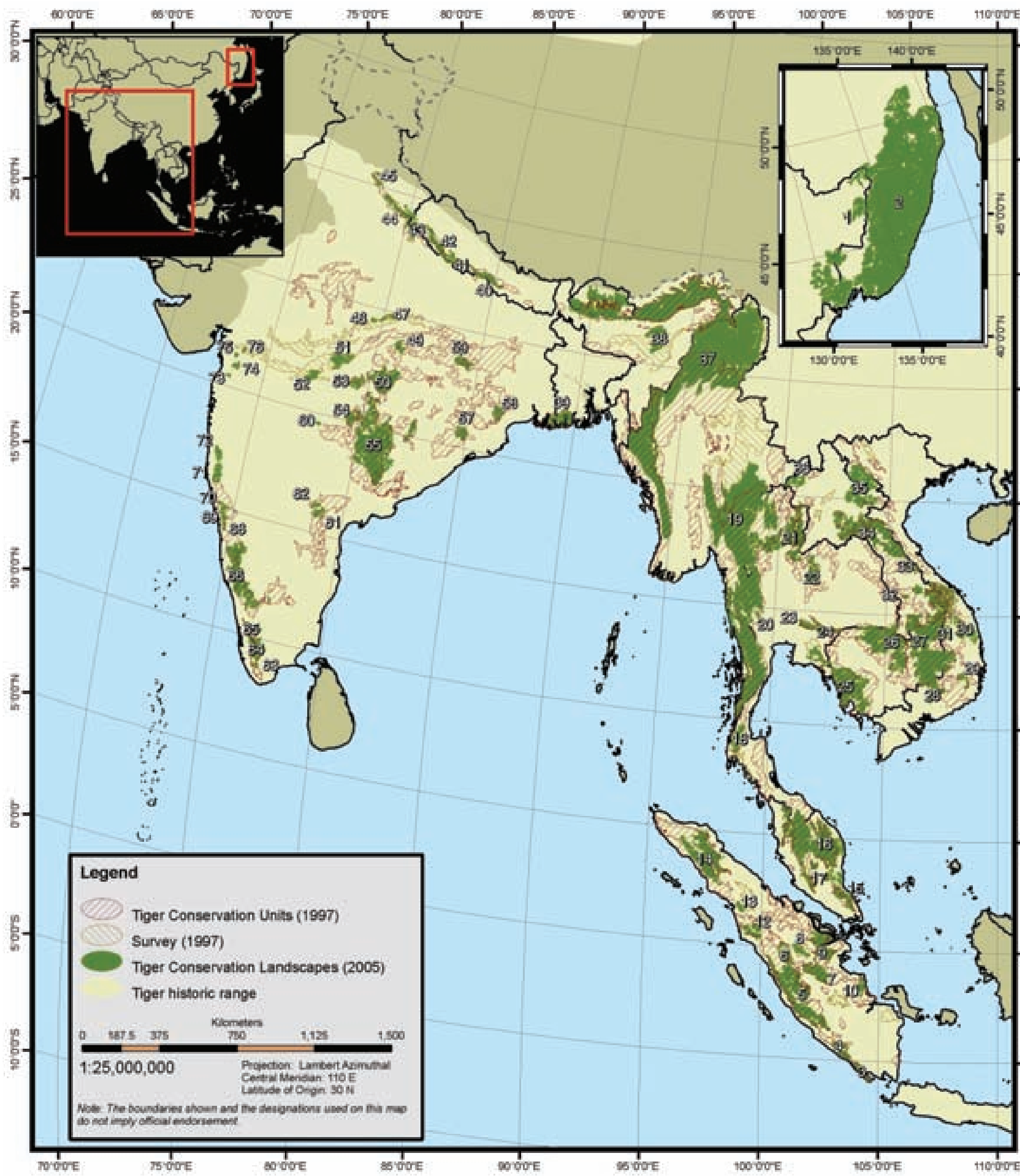

Fig 4.12 Comparison of TCL 2.0 to TCU 1.0

4.5.4 Recommendations arising from the delineation process

The way in which TCLs were defined and delineated lend themselves to certain management recommendations. Given the data we have assembled, these areas have been identified as the most important areas for tiger conservation, each harboring one or more tiger populations and the matrix of habitat and non-habitat area types where they exist. Within the TCLs themselves, we recommend that conservation strategies focus on securing existing tiger and tiger prey populations (particularly through protection and restoration of their breeding areas), protect existing tiger habitat from land conversion to agriculture and settlements, expand the current protected area network to encompass more of the tiger range in that area, and restore connectivity between patches of actual habitat within landscapes.

Our results indicate that TCLs tend to be clustered, offering the potential of forming even larger landscapes if connectivity between them can be reestablished. For example, there is a cluster of TCLs in the Terai Arc of India and Nepal; another set in central India; and another in central Indochina, including Myanmar, Laos, and Thailand. Such TCL clusters represent large expanses of suitable habitat interrupted by stretches of non-habitat more than 4 km.

Focusing conservation efforts on certain large TCLs will provide important fodder for saving tigers in the wild. For example, TCL #37 (Northern Forest Complex - Namdapha - Royal Manas) has the largest, relative area of 7,100 km^2 (with potential to support an estimated 35,500 tigers). It has within its boundaries six different biomes and crosses the boundaries of three countries. Conservation of this TCL will require transboundary cooperation and recognition of the different roles tigers play in different biome types. But successful conservation efforts in this area will go a long way towards achieving our goals for tigers.

A long-term tiger restoration strategy would seek to reconnect adjacent TCLs to increase the opportunity for tiger meta-populations to recover and persist. The success of such a strategy would also seek to reconnect survey and restoration landscapes as well as more fragmented potential habitat outside of landscapes with TCLs. Such reconnection could support tiger dispersal or even residence in the long-term.

Restoration landscapes are large areas of potential habitat of low human impact that have been surveyed in the past 10 years, with no evidence of tigers. As stated above, these landscapes would need to be managed in such a manner to restore tiger populations, either through reconnection with existing TCLs or through active tiger reintroduction.

Survey landscapes, like restoration landscapes, are large areas of potential habitat of low human impact. Unlike restoration landscapes, these landscapes have not been surveyed in the past 10 years (or have been surveyed but with results unknown to this study). Management recommendations are similar to restoration landscapes, with the added recommendation that the area be surveyed and results submitted to revise the delineation maps. Chapter 6 (Classification and Prioritization) provides further details on how investments and conservation efforts should proceed for TCLs, survey, and restoration landscapes.

More than 400 restoration (or extirpated) landscapes have been identified in China, central Asia, and Java, which make up extirpated parts of the tiger's historical range. These areas have been incorporated into the analysis as a reminder that these areas once supported tiger populations, some of which may be necessary to restore if we are to reach a goal of 100,000 tigers by 2100. While tiger habitat restoration strategies in the near term might not focus on these areas, it is important to remember that some large areas of potentially suitable habitat remain in China and central Asia.

4.6 Conclusions

As recently as 150 years ago, tigers ranged over vast areas of the Indian subcontinent, Southeast Asia, Indonesia (including Sumatra, Java, and Bali), China and Korea, central Asia, and the Russian Far East. Today, tigers range over only a small fraction (only 7%) of their former range. Current estimates of tiger habitat suggest a far more serious, albeit perhaps realistic, assessment of tiger habitat than the initial assessment, with current estimates 41% less than 1995 estimates. Of the tiger landscapes that remain, the majority do not have enough area to support a population of more than 100 tigers.

Tigers continue to range over a diversity of habitat types, but those favored by tigers—such as tropical moist and dry broadleaf forests in India and Southeast Asia and temperate mixed forest in the Russian Far East—are also some of the most common in Asia and favored by people. This competition with people in the tropical biomes mentioned limits tigers to 8 to 15% of that biome's area in the tiger's historic range.

The vast amount of tiger habitat remains in small landscapes under 10,000 km^2, with most landscapes only around 3,000 km^2. However, 15 large TCLs increase the average size of TCLs tremendously. More than half of the TCLs have more than one habitat type, so protecting these will also protect habitat diversity and niches for other species. Several TCLs cross political boundaries, causing each mainland country of the tigers current range to host a transboundary TCL. Indeed, effective solutions to transboundary management of TCLs in all of these countries will be a critical step to securing (and hopefully rebuilding) tiger populations into the future. Securing tiger populations and habitat in the largest TCLs will be critical to meeting the goal of 100,000 tigers by 2100—however, this will not be possible without effective transboundary conservation efforts.

Tigers are a species in crisis and have already lost much of the battle with humans. However, large areas of habitat remain and their populations are recoverable with successful conservation. Indeed, future development efforts that are zoned to occur outside of landscapes (including landscapes with and without tigers), that address tiger conservation issues in their development plans, and that observe potential connections between landscapes will go a long way to ensuring that humans, tigers, and other wildlife will be able to coexist on the same continent for years in the future.

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Colby Loucks, John Seidensticker, Timothy O'Brien

Chapter 5 Sensitivity Analysis

5.1 Introduction

In Chapter 4, we described the methods used to delineate tiger habitat across the range of the species. These methods were based on a priori decision rules in which criteria were selected based on the best available knowledge on tiger ecology and behavior. This standard set of criteria enabled us to maximize the use our current knowledge about tigers in an objective and consistent manner across the entire range, allowing us to compare the potential for conservation success in different areas where they live. During the delineation process, however, we were faced with many decisions when defining tiger conservation landscapes (TCL's) - challenges not unfamiliar to other species modeling efforts. Such challenges developed from uncertainties about the set of assumptions drawn from our current knowledge of tiger ecology used to guide the delineation, and questions about the accuracy and quality of data layers used in our analyses. Indeed, despite advances in research and knowledge on tiger ecology in the past 10 years, uncertainties remain about tiger dispersal patterns, sensitivity to human impact, density at carrying capacity in different habitat types, and how these characteristics might vary across the range. Moreover, problems arise with the accuracy and consistency of the data we do have. Although we made significant efforts to update the basic data inputs for this exercise (Chapters 2 and 3), we are aware of continued imperfections in the base data layers.

We realize that our limited understanding of tiger biology and ecology along with the recognized problems with datasets can have powerful implications on the delineation results and hence on financial and programmatic investments in tiger conservation. Our tiger conservation planning effort can, thus, benefit from the sensitivity analysis to better understand how sensitive our delineation results are to the choice of parameters. The analysis involves re-running our model to determine how the results vary in response to a change in one of the input parameters. This process can be useful for determining which input variables need to be estimated more carefully.

Variables that we decided to test include the human influence index, tiger dispersal distance between habitat patches, area of tiger presence defined by the radius from a point location, and minimum core area requirement. Sequentially adjusting individual thresholds of our model parameters allowed us to generate alternative TCL delineations. By knowing how the model responds to different parameter sets, we can make more informed decision about parameter choices and identify which factors are most important to research in the future.

5.2 Methodology for Sensitivity Assessment

For the sensitivity analysis we used an Arc/AML script to test 4 main parameters that affect the final delineation results: (1) human influence, (2) tiger dispersal distance (3) area of tiger presence and (4) minimum core area/stepping stone size. The baseline measures for those parameters were set at thresholds used in an early draft of the delineation and the sensitivity analysis was conducted by altering the value of one parameter at a time by an amount above and below its respective baseline values (Table 5.1). While testing each parameter we kept the three other ones constant at their initially set threshold. This provided us with an accurate way to examine the sensitivity of delineation results to a particular model input.

Sensitivity Tests	Parameter Sets					*Baseline values*
		Human Influence	Dispersal Distance (km)	Area of tiger presence-radius (km)	Minimum Core Area	
	Human Influence	**11 – 22**	4 km	20 km	Varies by habitat type	15
	Dispersal Distance (km)	15	**0, 2, 4, 6, 8, 10**	20 km	Varies by habitat-type	4 km
	Area of tiger presence-radius (km)	15	4 km	**2, 4, 5, 10, 15, 20, 25, varied (3-14)**	Varies by habitat-type	20 km
	Minimum Core Area	15	4 km	20 km	**100 km²**	Varies by habitat-type

Table 5.1 Delineation model parameters baseline and sensitivity anaylsis values. Parameter values that were varied are marked in bold.

Once our models were run and alternative tiger landscapes were generated, we used another Arc/AML script to derive statistics about output variables. Two main variables were examined 1) total number of TCLs, and 2) total area of all TCLs. We also derived statistics on percentage and rate of change of TCL count and area in response to each incremental adjustment to the input variables. Sensitivity was assumed to be high if there was an abrupt change in the output variables we measured. Below is a more detailed description of individual parameters and how their values were varied.

5.2.1 Human Influence Index

Human activities involving the direct persecution of tigers, hunting of the tiger's prey base or infrastructure development and associated with it land conversion constitute one of the key factors affecting tiger distribution across their range. To better represent the real situation on the ground and to avoid overestimating of tiger habitat, it is important for our delineation to exclude areas of human influence "too high" for species to withstand. The human influence index (HII) dataset, derived for the human footprint analysis, was used as a proxy for anthropogenic impact on the land and it was incorporated to investigate the relationship between the patterns of tiger distribution and the level of human pressure. The HII dataset represents the sum of influence from human population density, land transformation, accessibility, and technological development, and varies from 0 to 72 (Sanderson et al. 2002). HII value of 15 was derived from statistical calculations (see Chapter 4) to represent the most appropriate threshold for delineating areas with levels of human impact low enough to be considered suitable tiger habitat. Since there is uncertainty associated with assumptions behind the analysis, how tigers respond to human pressure in different habitats, and how the HII dataset represents real human impact on tigers, a sensitivity analysis was conducted to help us better understand the response of tiger landscapes to variations in the HII parameter value.

The landscape sensitivity analysis was run by altering the human influence index above and below its previously derived baseline HII value of 15 in the range from HII of 11 to HII of 22 while keeping dispersal, area of presence, and minimum core area values constant. We rerun the model by incrementing the value of human impact by one to account for all possible changes in the tiger response to small variations in human influence.

5.2.2 Dispersal Distance

Landscape connectivity is considered an important element of landscape structure because of its importance to metapopulation persistence. The difficulty surrounding the notion of landscape connectivity is that it must be assessed at the scale of the interaction between the particular species and the landscape and this interaction is not always fully understood. Moreover, variations in non-habitat type, prey availability, and cultural attitudes affect the friendliness of the matrix to tiger dispersal and associated dispersal distances in different parts of the range. The ability of tigers to move through non-habitat determines the degree of landscape connectivity and thereby affects the number and size of potential tiger habitats and TCLs. In the 1997 TCU 1.0 analysis, a simple and universal dispersal distance of 5 km was selected because of our limited information on tiger dispersal patterns in different types of habitats (Dinerstein et al. 1997). Because little new information on dispersal has emerged since that time, we selected the baseline distance of 4 km for TCL 2.0 to simplify complex habitat delineation calculations, at the same time recognizing the uncertainty on how this value represents the tiger's perception of the landscape.

Sensitivity analysis helped us thus examine the landscape response to the range of potential dispersal distances. We tested six different scenarios of delineation results adjusting the threshold distance—as in the case of human influence index—above and below the baseline value of 4 km. The dispersal range in the model was varied from 0 km, where we assume tigers are unable to move across the unsuitable habitat, to a value of 10 km where the entire range was assumed to be highly connected and tigers could easy travel across non-habitat areas. The model was rerun with 2 km increments, while human influence, distribution, and minimum core area parameter values were kept at their baseline values.

5.2.3 Area of Tiger Presence

The area over which a tiger identified at a particular point will range is represented in our model by a circular radius around a tiger point location. For the baseline input for this delineation, we assumed that a tiger found at a given point location could be found at any location within 20 km of that point[1] (within an area of 1,256 km^2). In reality, however, the tiger distribution can vary quite drastically across its extent and a tiger's home range is contingent in part on such factors as the habitat type it uses, the season or social structure. As noted in Chapter 4 there are also some problems with the tiger distribution data that were compiled from different sources leaving many gaps in our knowledge about tiger presence or absence in a part of its range.

Bearing in mind those uncertainties, we wanted to test how our assumptions about area of tiger presence affect the delineation results. First, we ran the model with the small area of tiger presence with radius from the point location set at 2 and 4 km (representing tiger presence areas of 13 and 50 km^2, respectively) Then, we reran the model with radii ranging from 5 km to 25 km (representing tiger presence areas of 79 km^2 to 1,963 km^2), incrementing the radius by 5 km. In order to better reflect the large variation in tiger biology and behavior in different types of habitat, we also ran the delineation model with variable radius ranging from 3 km to 14 km (representing tiger presence areas of 30 to 625 km^2), depending on where the tiger point was in relation to habitat type. We applied smaller radii to tiger points found in habitat types that support higher densities of tigers, and larger radii to tiger points found in habitats that support lower densities, consistent with the tiger densities by habitat type defined in Chapter 4. The three other variables, human influence index, dispersal distance, and minimum core area remained fixed at the baseline value through all model runs. Since, the radius around the tiger location points was not increased by a constant value, calculating simple percentage change in number and area of TCLs would not allow us to accurately interpret results. Instead, we calculated the rate of change in count and area of TCLs per change in the radius used to derive area of tiger presence.

5.2.4 Minimum Core Area and Stepping Stone Patch Size

Early delineation efforts were based on the constant minimum core area set to 100 km^2 and stepping stone size set to 10 km^2. In our final delineation the minimum area varied from 30 to 625 km^2. and was based on the variation of tiger densities in different habitats. Stepping stone patches were scaled at 10% of the size of the core area with a range between 3 to 62 km^2. For our analysis, we investigated changes in the tiger landscape structure once we reran our delineation model with the minimum core area and with stepping stone size at constant value of 100 km^2 and 10 km^2 respectively. We ran

[4] This radius was selected initially because in our survey of tiger experts for the tiger conservation database (see Chapter 2), we asked them to submit tiger survey results for a 20 km radius. In actuality, experts submitted data in many formats, ranging from one point per survey location or tiger sighting to one point per 20 km radius.

this scenario while keeping human impact threshold, connectivity, and density at their baseline values.

5.3 Sensitivity Analysis Results

5.3.1 Human Influence Index

Altering the threshold of human influence index between the HII value of 11 and HII of 22 reveals a change in the number of TCLs across the tiger range (Figure 5.1). As we increase the HII threshold from 11 to 17 the total number of TCLs changes from 27 to 65 landscapes. However, as shown in Figure 5.1, the response of the landscape structure to variation in HII threshold is not gradual. The sensitivity analysis identifies an abrupt change between HII threshold values of 13 and 14 where we note a 57% increase in the number of TCLs from 27 to 63 (Figure 5.2). Further increase in HII threshold does not

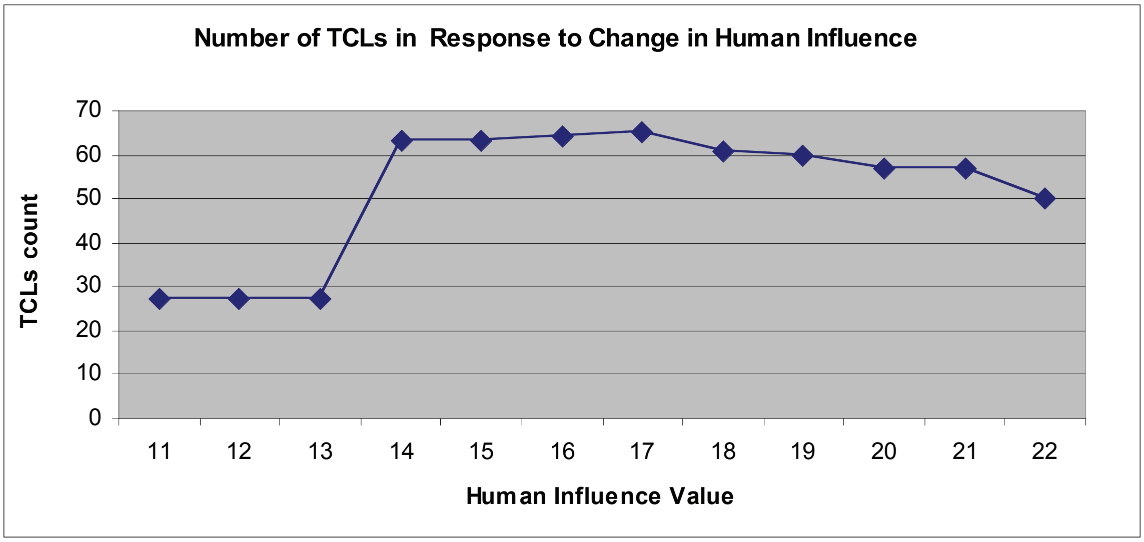


Figure 5.1 Number of TCLs in response to increasing human influence threshold values. Lower HII threshold indicates lower tolerance by tigers to human pressure.

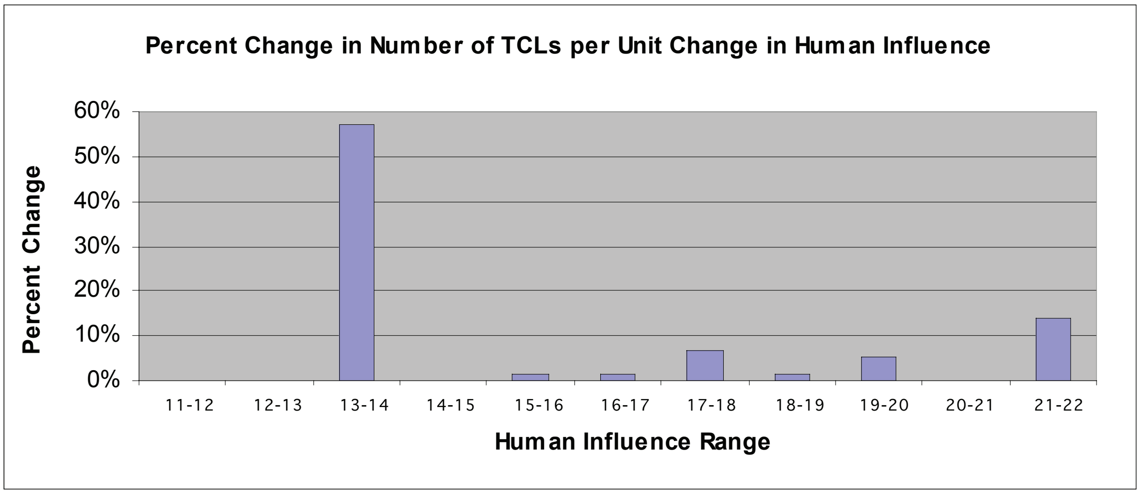


Figure 5.2 Percent change in the number of TCLs in response to increasing human influence threshold values.

have as much impact on the count of suitable tiger habitats. The total number of TCLs remains relatively the same through the rest of the iterations and it drops slightly to a total of 50 landscapes as HII threshold approaches value of 22.

Increasing the human impact threshold values also corresponds to an increase in the total area of TCLs, as the model finds more suitable habitat available for tigers. Although the sensitivity analysis does not identify such drastic variation in the area values as it did for the total number of TCLs, the overall area of TCLs is still most sensitive to HII threshold adjustment from 13 to 14. The HII adjustment between those values results in the change in TCLs size from 1,054,990 km² to 1,295,500 km² representing an increase in total TCL area by as high as 18% (Figure 5.4)

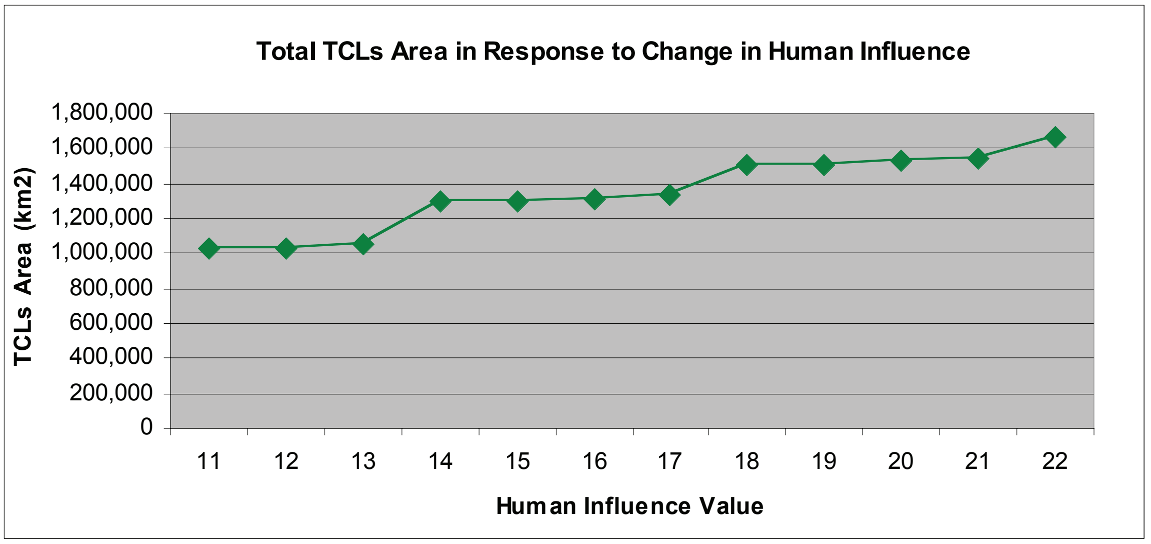


Figure 5.3 Total area TCLs in response to increasing human influence threshold. Lower HII threshold indicates lower tolerance by tigers to human pressure.

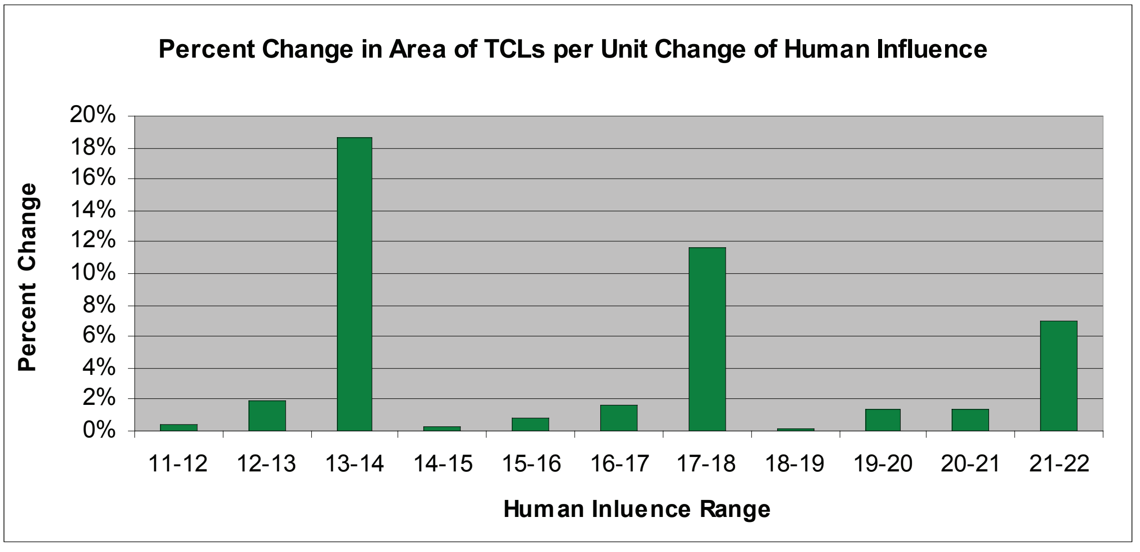


Figure 5.4 Percent change in the total area of TCLs in response to increasing human influence threshold values.

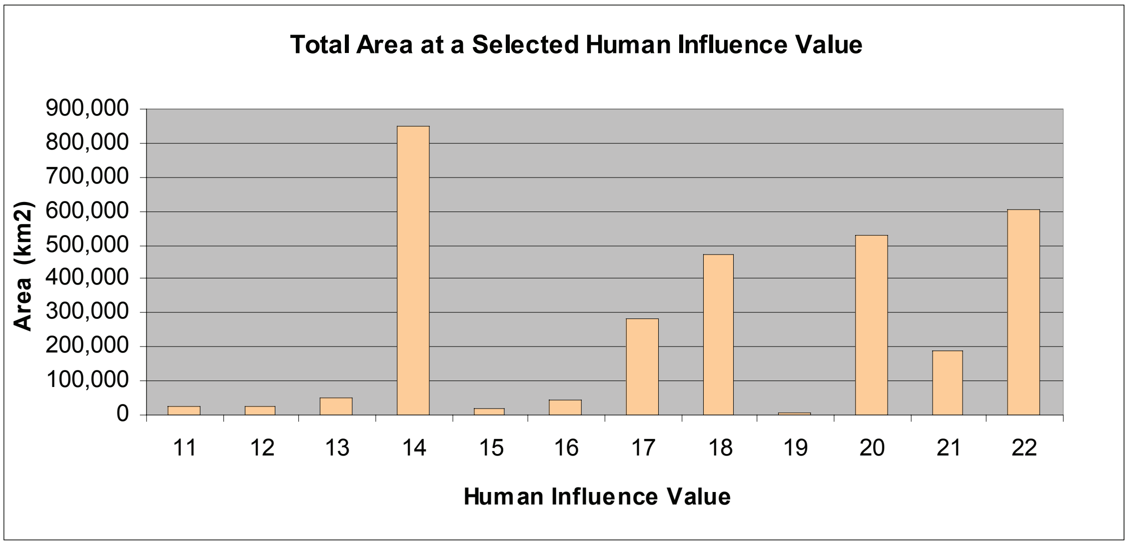


Figure 5.5 The total area within the current tiger distribution at a specific human influence value tested in the sensitivity analisis.

Overall, increasing the HII thresholds assumes a higher tiger tolerance to human pressure and it leads to an increase in the number of tiger landscapes and the area of suitable habitat with the highest landscape sensitivity noted between HII thresholds of 13 and 14. It is important to recognize, however, that the human influence index grid itself has an uneven distribution with a maximum amount of change in area between HII 13 and 14, which undoubtedly affects the results of this sensitivity analysis (Figure 5.5).

5.3.2 Dispersal Distance

Increasing the tiger dispersal distance parameter value from 0 km to 10 km by a 2 km increment results in a gradual decrease in the number of TCLs across the entire tiger range. A dispersal distance threshold of 0 km represents tigers completely avoiding any unsuitable habitat. Consequently, the delineation model run with this input parameter generates a highly fragmented landscape with as many as 87 isolated landscape patches. On the other hand, setting the dispersal parameter to its maximum value of 10 km expresses the ability of tigers to traverse a relatively large distance of non-habitat. At this parameter, the resulting landscape consists of only 37 tiger patches—that is, fewer, but larger and more connected TCLs. (Figure 5.6). Although, sensitivity analysis does not indicate any abrupt change in the landscape structure to varying the parameter value, the delineation results seem to be most responsive to dispersal thresholds between 4 km to 6 km, where the number of TCLs drops from 63 to 48 (31% change) (Figure 5.7).

As the dispersal threshold increases, the number of TCLs declines, but the total area of TCLs expands (Figure 5.8). Again, there is no abrupt landscape response to the varied dispersal values, however, as in the case of the count of TCLs, the highest percent change in the area is found between the dispersal thresholds of 4 and 6 km. The total area of TCLs is enlarged by 13% from 1,298,590 km^2 to 1,515,678 km^2 (Figure 5.9).

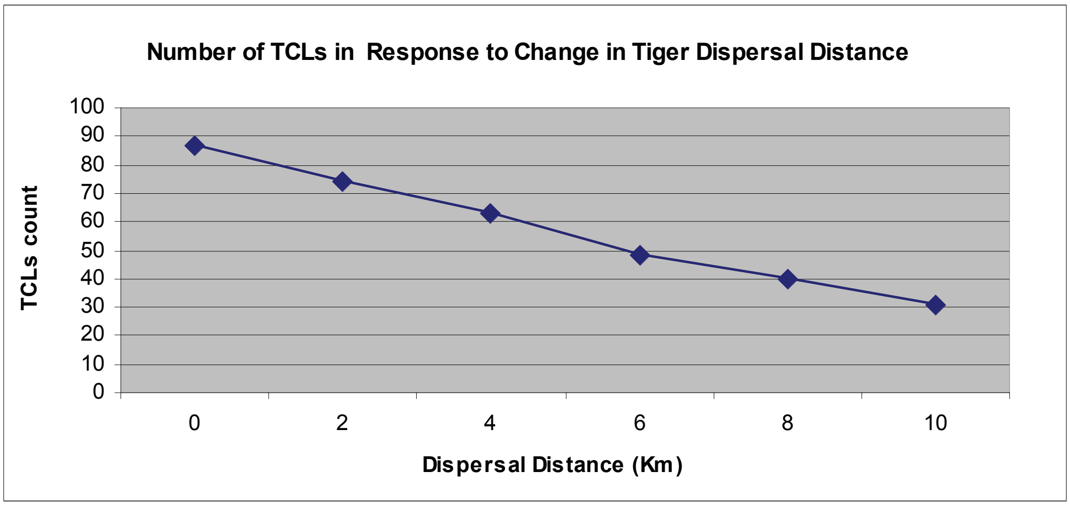


Figure 5.6 Numer of TCLs in response to the change in the tiger dispersal distance.

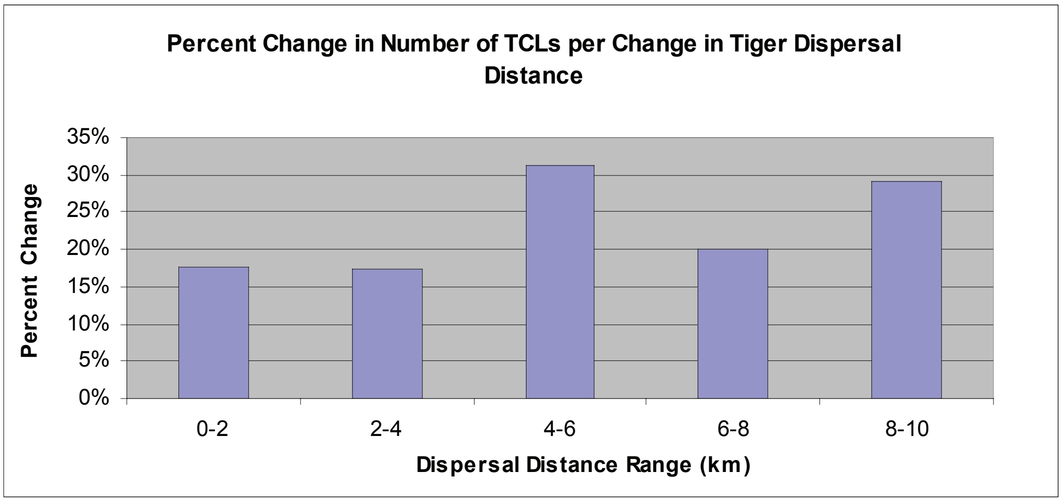


Figure 5.7 Percent change in the number of TCLs in response to the change in the tiger dispersal distance.

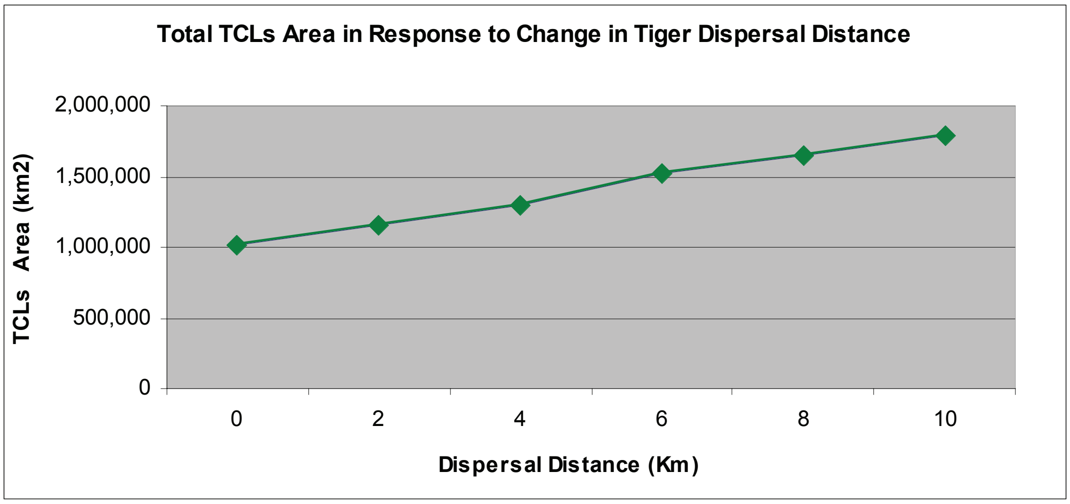


Figure 5.8 Total Area of TCLs in response to the change in the tiger dispersal distance.

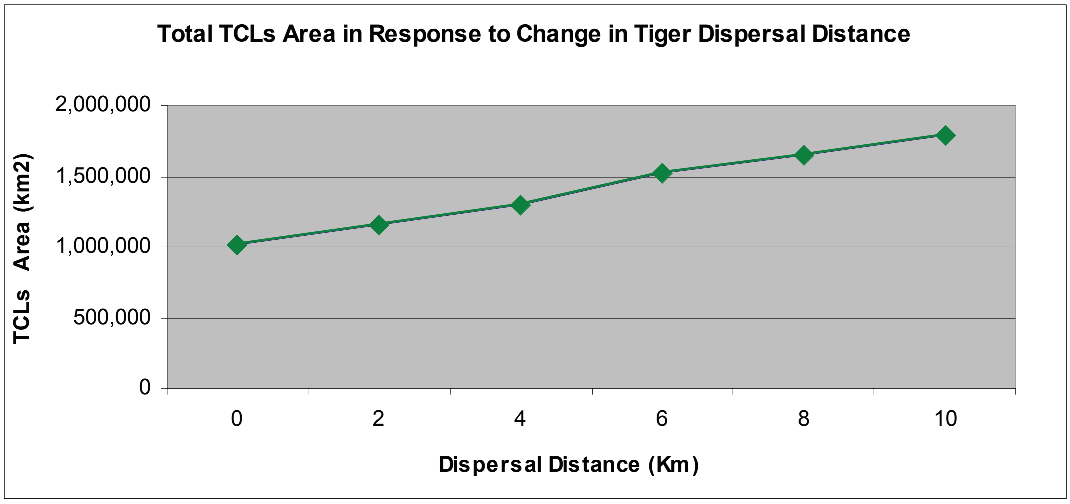


Figure 5.9 Percent change in the area of TCLs in response to the change in the tiger dispersal distance.

Figure 5.10 shows an example of the effect of adjustments in the dispersal distance on the landscape structure in the eastern part of India. Varying the distance parameter between 2 and 4 km does not lead to any drastic changes in the delineation results (Figures 5.10A and 5.10B). However, the adjustment of the dispersal threshold from 4 to 6 km has much more effect on the landscape configuration (Figures 5.10B and 5.10C). Once the parameter is set at 6 km, TCL #55 (Indravati) becomes substantially larger by encompassing additional patches of effective habitat to the south, east and west. In addition, the model results reveal the delineation of two major habitat corridors between TCLs #51 (Pachmarhi-Satpura–Bori) and #52 (Melghat) and between TCL #50 (Kanha-Phen) and TCL #53 (Pentch) leading to the creation of two instead of four TCLs. These two newly created TCLs are further enlarged by connecting with surrounding habitat patches. Finally, the inclusion of additional habitat into the TCL #59 contributes to its size expansion and to the development of potential for the connectivity with TCL #49.

As we increase tiger dispersal capabilities in our models, not surprisingly the entire landscape becomes gradually more connected with fewer and larger habitats. Still, neither quantitative nor visual assessment of different landscape scenarios indicates any abrupt change in the landscape response to the higher dispersal values (Figures 5.10C-E).

5.3.3 Area of Tiger Presence

The response of the TCL delineation to changes in the area of tiger presence is complicated. The number of TCLs delineated with different settings for the modeled area of tiger presence leads to non-linear and not easily predictable results. The largest change in the TCLs count from 69 to 63 is noted between radii of 10 and 15 km (Figure 5.11). This drop in TCLs number could potentially indicate relatively high landscape sensitivity in this range of values. However, since the increase in the parameter value is not kept constant, the rate of change in the TCLs count per change in the area of presence can

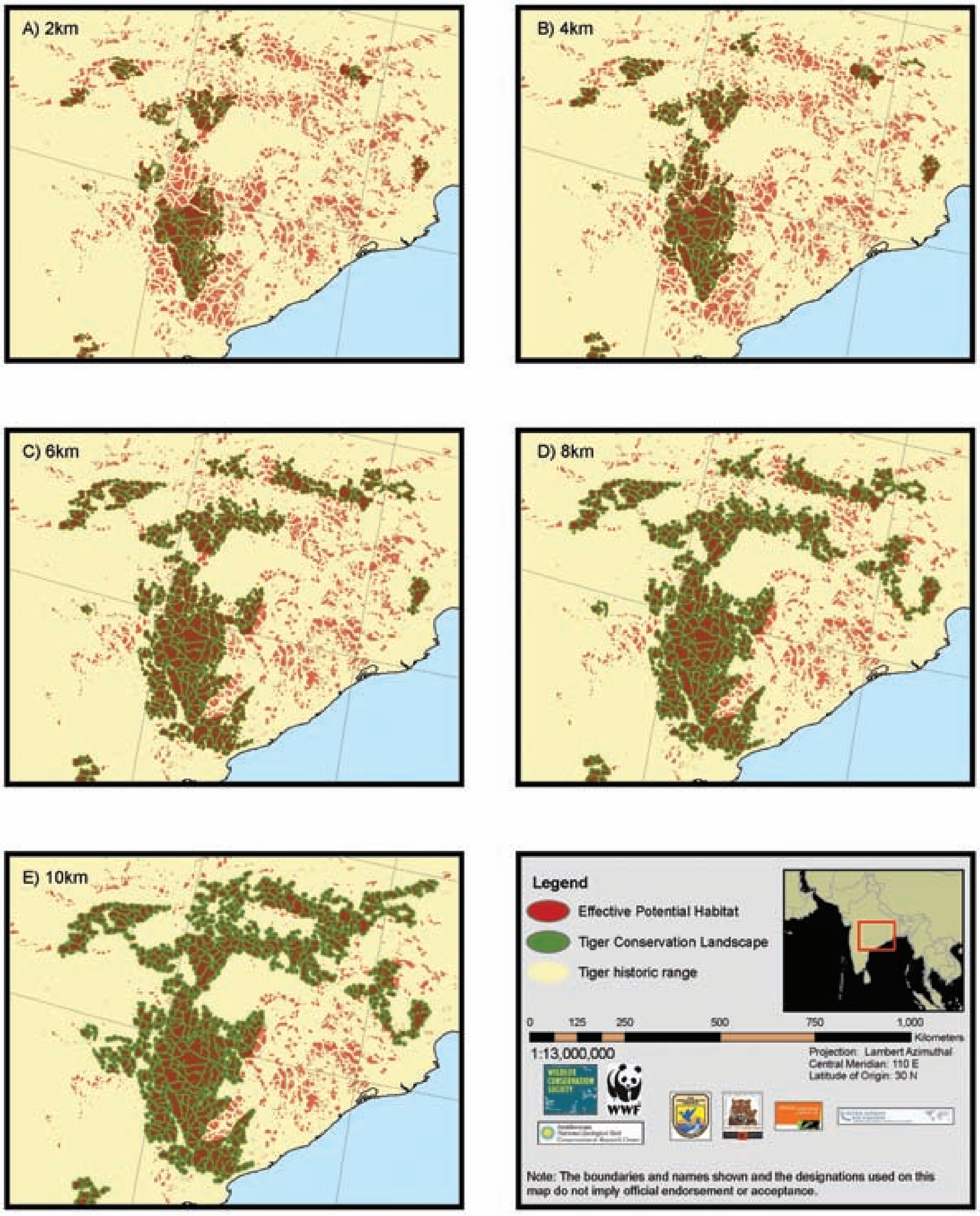


Figure 5.10 Demonstration of effects of changes in the dispersal distance values on the number and the area of TCLs in the eastern part of India. Results are from analyses with earlier data and do not represent selected TCLs.

provide more accurate interpretation of results of our model than simple percent change in the number. As Figure 5.12 shows, the highest rate of change in count of TCLs is noted between radii of 4 and 5 km, as the number of TCLs increases, and again between radii 10 and 15 km once the total count of TCLs drops more significantly. Subsequent model scenarios with an increase in radius to 25 km show that the number of TCLs slightly increases but remains in the range of 64 to 65 TCLs. The low variations in the number of landscapes correspond to low rates of change per area of tiger distribution.

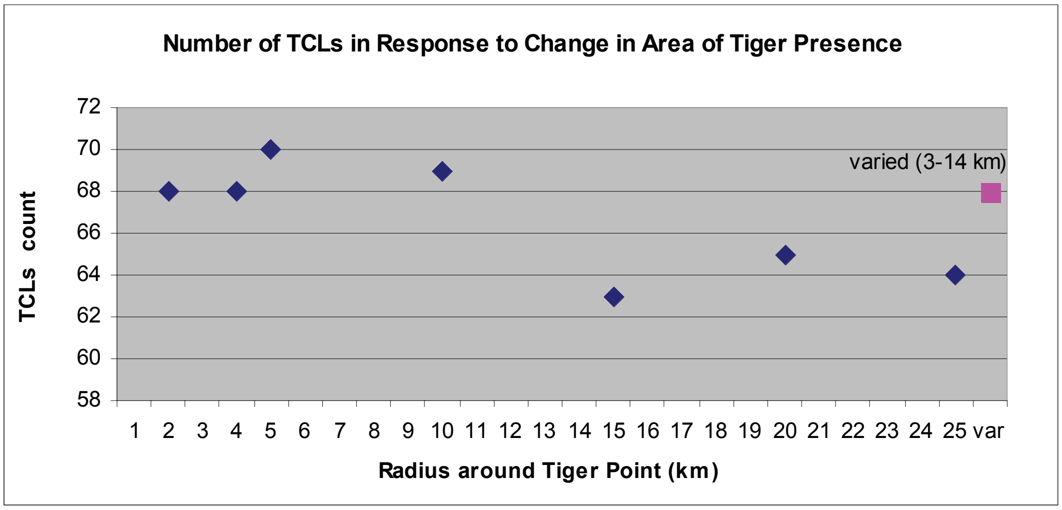


Figure 5.11 Number of TCLs in response to change in the area of tiger presence defined by the radius around the tiger location point.

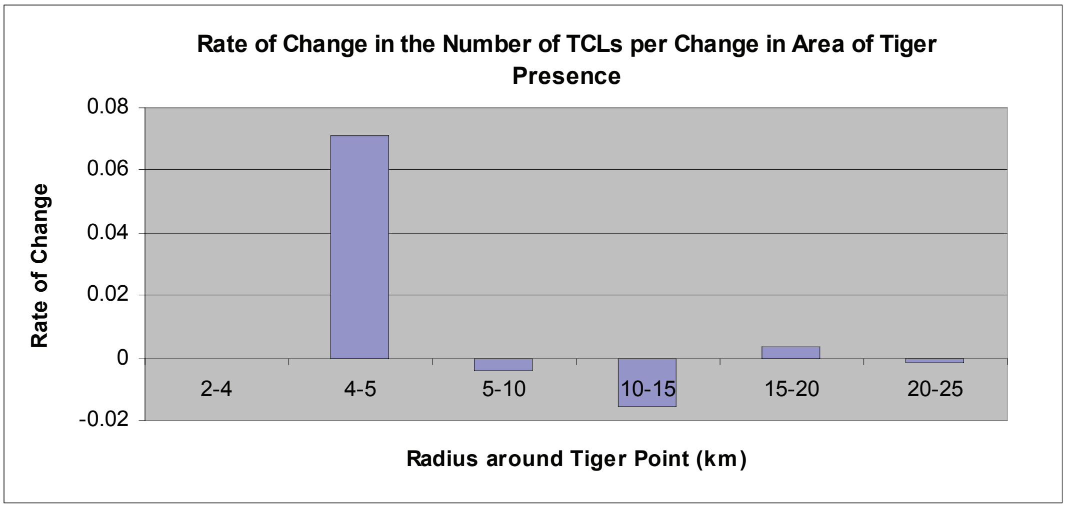


Figure 5.12 Rate of change in the number of TCLs per change in the area of tiger presence defined by the radius around the tiger location point.

The delineation model employed in TCL 2.0 has a variable radius depending on habitat type ranging from 3 to 14 km (reflecting area of tiger presence from 30 to 625 km^2). The resulting from this model landscape consists of 68 TCLs. This is a similar number of TCLs generated by the model run with radius values set between 2 and 10 km (Figure 5.11).

TCL area follows a different response curve to TCL count. The overall TCL size increases in response to increasing area of tiger presence, except for a small drop in the area between parameter values of 2 and 4 km (Figure 5.13). According to Figure 5.14 the highest rate of change in the total TCLs area per change in the area of tiger presenceis between radii of 4 and 5 km. This also corresponds to the highest rate of change in the total TCLs count.

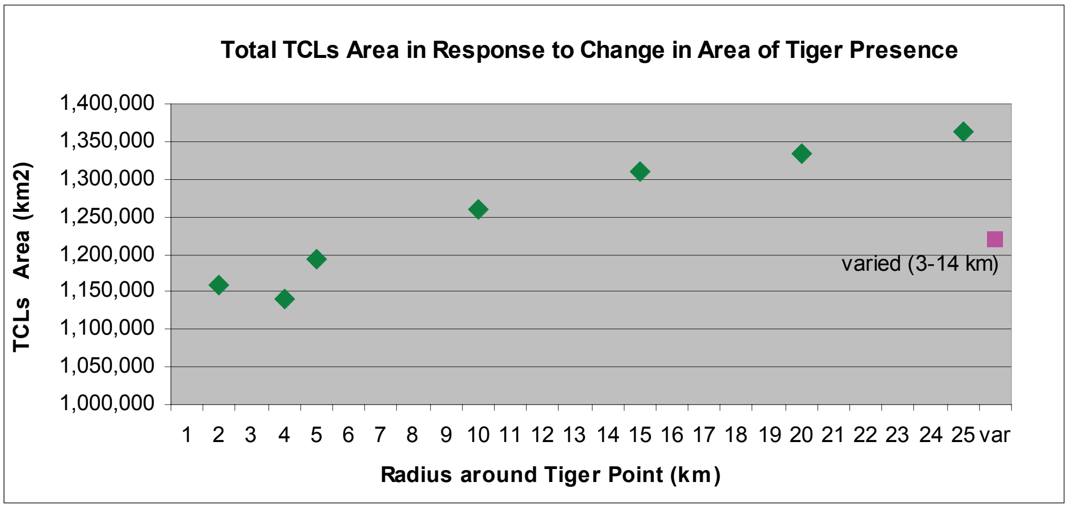


Figure 5.13 Total area of TCLs in response to change in the area of tiger presence defined by the radius around the tiger location point.

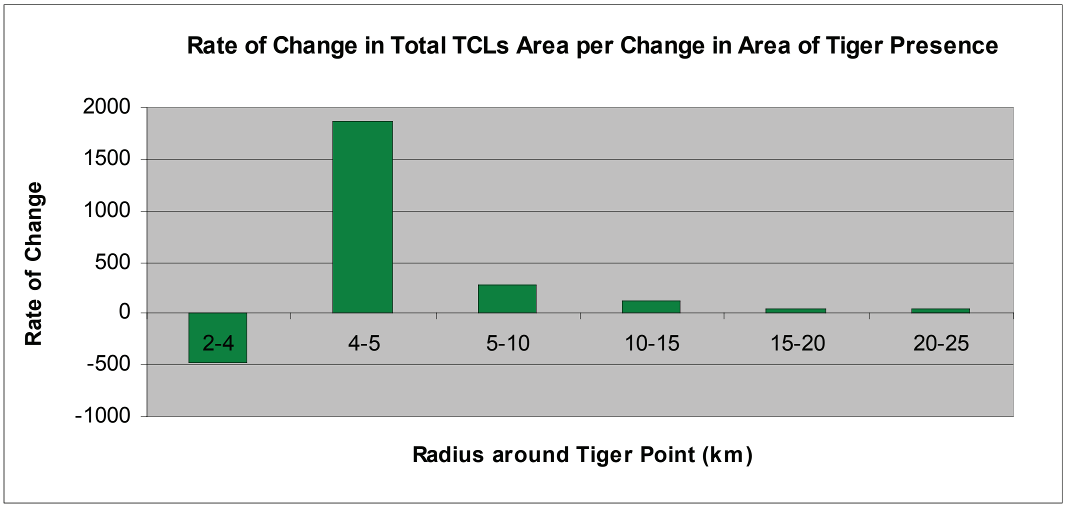


Figure 5.14 Rate of change in the area of TCLs per change in the area of tiger presence defined by the radius around the tiger location point.

The analysis also reveals slightly higher landscape sensitivity to adjusting the parameter value from 5 to 10 km while the area of tiger landscapes expands from 1,193,674 km^2 to 1,260,413 km^2. Once the model was re-run with varied radius between 3 and 14 km, the total TCL area equaled 1,220,965 km^2. The total size of TCLs resulting from this model falls within the range of the sizes of TCLs derived from running the sensitivity analysis with the radius set at 5 km and 10 km (Figure 5.13).

5.3.3 Minimum Core Area and Stepping Stone size

We did not find any significant difference in the landscape structure response to the change in the minimum core/stepping stone area model assumptions (Table 5.2). The number of TCLs and their size remained almost the same.

Minimum Core and Stepping Stone Area	# TCLs	Total TCLs Area (km²)
Constant (100 km²/10 km²)	64	1,324,510
Variable between 30 and 625 km² (depending on the habitat type)	63	1,298,590

Table 5.2 Sensitivity analysis results for minimum core area and stepping stone size assessment.

5.4 Discussion of Sensitivity Results

It is obvious that any mathematical model is sensitive to its inputs; however, sensitivity testing of spatial habitat models like this one is the exception, not the norm. For our sensitivity analysis we varied four parameters in order to determine which had the most influence on the results of the delineation model. The variables we tested included (1) human influence, (2) tiger dispersal distance, (3) area of tiger presence, and (4) minimum core area/stepping stone size. The analysis was conducted to help us refine the model input variables to derive the most appropriate results that approximate the situation on the ground. In the process we recognized the need for careful interpretation of the model outputs due to uncertainty associated with all input parameters and their complex interactions on the landscape level. Sensitivity of the model to the variation in above variables is a combination of (1) the landscape structure, (2) tiger biology, and (3) the data quality associated with both of those issues. Problems related to the accuracy and consistency of the datasets we have as well as gaps in our knowledge about tiger biology can also affect our prediction of suitable tiger habitat and its response to the landscape structure. Still, the sensitivity analysis provided us with an important insight into the influence of individual input parameters on the tiger's range.

5.4.1 Human Influence Index

Clearly the human influence index threshold has a powerful effect on the number and size of TCLs and thus the future conservation recommendations for the tiger range. The selection of the appropriate threshold constituted a crucial aspect of our delineation analysis. On the one hand, it was important not to select the threshold that is too low that could result in the elimination of a large expanse of potential tiger habitat from TCLs. On the other hand, we had to be careful not to set the HII threshold too high to produce false results by incorporating the areas where tigers are no longer thought to occur. The threshold analysis (see Chapter 4) determined the threshold to be at the HII value of 15. The sensitivity analysis allowed us to test the landscape response to human influence values below and above this threshold and either identify a new potential threshold or confirm our previous results of threshold analysis.

As expected the number of TCLs and their size increased with increasing human influence threshold values, reflecting a higher tolerance by tigers to human pressure, therefore "opening" larger areas to their use. The abrupt change in the total area of TCLs as the response to increasing the human influence index from HII value of 13 to 14 shows high landscape sensitivity to this threshold level. The change in the total area is not as drastic and it reveals a three-tiered response where the model is most sensitive to HII change between values of 13 and 14 and then again between HII values of 17 and 18. We recognize, however, that the results of the analysis in some part reflect the fact that the human influence index itself has a non-linear distribution with different total areas at each HII value, which occurs as a result of the scoring system applied to layers used to create the human influence index map. Due to this non-linear distribution of the human influence values, we note that changing the HII threshold between 13 and 14 may represent more "real" change in human impact rather than the "real" change in tiger response to variations in HII values.

In this context, we can still make conclusions about how tigers in the wild might respond to increasing or decreasing human impact. For the purpose of the final delineation presented in this report, we selected human influence index value of 15 based on the HII threshold analysis (Chapter 4). If we assume that the HII value of 15 represents the current situation on the ground, then our sensitivity results indicates that further development or any other types of human impact could have a severe negative effect on the future tiger persistence since the number of TCLs and their total area shrinks significantly. On the other hand, we can assume that if higher influenced areas are made more usable for tigers we can potentially create larger areas of tiger habitat. Policy interventions, for example, that make poaching less likely or lessen conflict between people and tigers may greatly expand the amount of habitat available for tigers.

5.4.2 Dispersal Distance

Improving habitat quality and developing dispersal corridors between suitable habitats is imperative for tiger persistence across their range. The sensitivity analysis supports the conclusion that increasing tiger dispersal capabilities leads to fewer but larger and connected habitats and less fragmentation. There were no obvious discontinuities in the sensitivity results. Still, the model showed slightly higher sensitivity to changes in the parameter values from 4 to 6 km. For example in the eastern part of India, when the dispersal distance was set at 6 km, the total area of TCLs expanded by encompassing surrounding habitat patches and by connecting with each other. Once the distance was increased above 6 km, the rate of change remained relatively the same.

Since the sensitivity analysis did not reveal any threshold that significantly influenced the output variables, we decided to maintain the initial dispersal distance value set at 4 km and err towards less connected landscape since over much of the tiger's range, tigers that leave a habitat block are often at great risk of being killed before they can reach a second suitable habitat block. Since landscape connectivity is considered to be an important factor determining population survival, the tiger interaction with the landscape must be better understood. Further research has to be undertaken to explore how habitat structure, level of human disturbance and human attitudes affect tiger dispersal patterns and thus affect their distribution across the range.

5.4.3 Area of Tiger Presence

The area of tiger presence in our model is represented by the radius around the tiger point location. Initially and in our baseline studies for this chapter, we assumed that a tiger searched for at a given point location could be found at any location within 20 km of that point. The same threshold was used for other species in the rangewide priority settings efforts as a standardized value. Our initial decision rule was thus weighed towards overestimating the extent of the existing known tiger range. In reality the tiger extent may be much smaller and may vary depending on the on habitat quality, prey availability, the tiger's sex, and the season.

Our sensitivity analysis revealed a complex response of the landscape to the area of tiger presence parameter. For TCL 2.0, we ultimately selected a variable radius depending on habitat type. The choice of this variable parameter also falls in the mid range of the parameter values (4 to 15 km) that led to the highest rates of change in the total count and area of TCLs. Still, it is not clear exactly what drives the range-wide response of area of presence to the tiger conservation landscapes delineated except that it is related to the distribution of habitat patches, their inter-patch distance, and the locations of tiger points, as recorded in the tiger database. There may be biome or bioregional specific response to any and all of these relationships. Further study is required to better understand the tiger-landscape interactions.

5.4.4 Minimum Core Area and Stepping Stone Size

As with the thresholds related to human influence index, dispersal distance and tiger distribution radius there are also some uncertainties associated with the area required to support a viable population of tigers. An early draft of the current delineation applied the rule of minimum core area of 100 km^2 and stepping stone size of 10 km^2. For the delineation of TCLs presented in TCL 2.0 we used results of research on tiger densities to determine both minimum core area and stepping stone size requirements. Since tiger density varies depending on the type of habitat the tiger uses, the minimum core area size was selected based on the area requirement to support at least 5 tigers over 1 year old and it was stratified by habitat type. The resulting minimum area varied from 30 to 625 km^2. Stepping stone patches were scaled at 10% of the size of the core area with a range between 3 to 62 km^2.

Sensitivity analysis indicated that there was not much difference in the number of final TCLs and their total area depending on core minimum area definitions. Even though the differences are not significant, the decision to adjust the core area depending on the habitat type is more appropriate in terms of defining the tiger biology and behavior across its range.

5.4.5 Interactions between parameter choices

Although the model sensitivity for each factor can be studied in isolation, it is also important to understand how they interact. Table 5.3 presents the relationship of the final delineation results from TCL 2.0 to the various sensitivity tests presented here. The final set of parameter choices for TCL 2.0 leads to a larger number of TCLs than any one of the other sensitivity tests, however the total area of TCL found is in the middle of the range. As a consequence our final maps may emphasize slightly more fragmentation than other methods, but with the benefit of providing more choices in terms of tiger conservation investment strategies.

Parameter Sets / Sensitivity thresholds	Human Influence	Dispersal Distance (km)	Area of tiger presence - radius (km)	Minimum Core Area	*Total Count of TCLs*	*Total Area of TCLs (km^2)*
Human Influence threshold	**14**	4 km	20 km	Varies by habitat type	*63*	*1,295,500*
Dispersal Distance threshold (km)	15	**6 km**	20 km	Varies by habitat-type	*48*	*1,515,678*
Area of tiger presence -radius threshold (km)	15	4 km	**5 km**	Varies by habitat-type	*70*	*1,193,674*
Baseline values	*15*	*4 km*	*20 km*	*Varies by habitat-type*	*63*	*1,298,590*
Final model parameters	*15*	*4*	*3-14 km*	*Varies by habitat-type*	*76*	*1,184,911*

Table 5.3 The total area and count of TCLs at the parameter values leading to a higher model sensitivity. The threshold parameter values are marked in bold.

The delineation model results are hampered by gaps in our knowledge about many factors that are related to tiger conservation. The tiger dispersal and ranging patterns, which in part are determined by the human activities, have significant effect on how tigers use the landscape and respond to its changes. Sensitivity analysis helped us identify important parameters and test assumptions about tiger ecology and behavior, and it revealed that, in some cases, small changes in the parameter values could yield significantly different results in the availability of suitable habitat. Table 5.3 shows the total area and count of TCLs resulting from the model run with parameter values that had the strongest impact on the delineation patterns, compared to other tested values. Results of our analysis indicate that the highest model sensitivity was recorded once we varied human influence index and the area of tiger presence parameter thresholds. The landscape structure defined by the number and area of TCLs has changed more significantly at the HII value of 14 and at the area of tiger presence determined by the radius of 5 km. Significant variations in the model results indicate the need for careful assessment of those parameters and thus for more research to better understand the tiger response to the human pressure or prey dynamics. At the same time, the high sensitivity of the model to these parameters shows that improvements in habitat quality—by reducing threats to tigers from poaching or prey depletion, by changing peoples attitudes or by securing prey availability—can help tigers expand their ranges and withstand higher human impact, and consequently increase chances for their persistence.

The adjustments in the dispersal distances, although they yielded different delineation results, did not lead to abrupt changes in the tiger landscape, but rather caused a smooth transition in the count and size of TCLs with each subsequent increment. The model showed only slightly higher landscape sensitivity once the tiger dispersal distance was increased from 4 to 6 km. Nevertheless, the dispersal distance parameter, once set to 6 km, led to significantly different delineation results than the ones obtained from the models run with baseline values. It resulted in a highly connected landscape composed of 48 TCLs with a high proportion of suitable habitat encompassing an area as large as 1,515,678 km^2. Based on the results, we may assume that even a slight improvement in the habitat quality—by restoring dispersal corridors or by minimizing human pressure in non-habitat areas—can significantly enhance our long-term tiger conservation strategies.

5.5 Conclusion

Sensitivity analysis is an under-used tool in species conservation planning. As we demonstrate here, sensitivity analysis can inform the complicated set of choices made in modeling species distributions across the range. Although sensitivity analysis does not tell us what to do, it does inform the consequences of our choices in terms of model performance. For tigers, we have just scratched the surface. There is still uncertainty related to the impact of individual parameters, their complex interactions at various locations of the tiger range, and their ability to represent the real situation on the ground. Sensitivity analysis should be geared toward identifying parameters that, if known with a higher precision, would decrease the uncertainty in our delineation model. Further data exploration is therefore warranted, particularly to examine how data in different ecological settings may be differentially sensitive to the parameter choices made.

— Gosia Bryja, Jessica Forrest, Eric Sanderson

Chapter 6 A New Taxonomy for Tiger Conservation Landscapes: Setting Classes and Priorities for Tiger Conservation

6.1 Introduction

After delineating tiger conservation landscapes, the next important step is to set priorities among them. Setting priorities for tiger conservation landscapes means giving the tiger conservation community clear, practical recommendations on which areas are most important for conservation of tigers over the next decade, while looking toward the value of these landscapes to tigers for the long term. Tiger conservation landscape priorities reflect our goals, our ability to measure progress toward those goals, and an assessment of the places where we can most likely succeed.

When establishing criteria for prioritization, we need to keep in mind several factors. First and foremost, what are our goals for tiger conservation, now and in the future? Second, based on current understanding of tiger conservation biology, what is important for long-term tiger survival in an area and across the range? Third, how do priorities from TCL 2.0 compare to priorities established in TCU 1.0? All these considerations should be addressed in our new taxonomy for identifying tiger conservation areas, and our mechanisms for prioritizing them.

6.1.1 Goals for tiger conservation

A few years ago, the Wildlife Conservation Society adopted a long-term goal of having 100,000 tigers across the historical range by 2100 (Ginsberg 2001). Given the current state of tiger conservation, which remains dire, this goal does indeed seem far away, though we should remember that less than 125 years ago, places like Chitwan were producing tigers at a prodigious rate. Having such a long-term vision, however, helps guide us in making investment decisions. While we may focus in the short term on securing existing breeding populations, we also need to consider how those populations might eventually contribute to the establishment of healthy regional metapopulations across all parts of the tiger range.

In the meantime, we need to recognize the current realities of tiger conservation. The realities suggest that the few tigers that live today in the wild persist in small, isolated populations, mainly in protected areas, where they continue to live under threat from direct mortality, prey depletion, and habitat loss. In major parts of their range they have been extirpated during the twentieth century, notably in central Asia, islands of Indonesia, and in China. The only exception to this overall gloomy trend is the Russian Far East, where interconnected, breeding populations persist, though recent work suggest that even these populations may be more subdivided that we would like.

In short, tigers are still in trouble. Thus our most immediate goals should focus on securing existing breeding populations in large areas of habitat wherever we can find them.

Breeding populations are the fundamental building block of any tiger conservation strategy. In the longer term, these populations will be the basis for developing interconnected tiger meta-populations across habitats and regions, and eventually to restore tigers to all parts of the historical range. However our most immediate goal must be to identify and work to conserve breeding populations.

As in our previous priority-setting exercise (Dinerstein et al. 1997), these populations need to represent the different ecological situations where tigers were historically found. We want not only to conserve tigers as set-pieces, but tigers as dynamic, functional actors in the settings where they occur; we want to conserve representative "tigerness" in all its diversity of circumstances, from the grasslands of Nepal to the conifer forests of Russia. Moreover, setting priorities across different habitat types and bioregions will ensure that we conserve populations across the historical range that serve as a foundation on which to build a successful range-wide program of conservation and restoration.

We know that tiger populations need prey and safe habitat to survive. Research over the past decades has shown that tigers require abundant prey, and some structural cover (trees or tall grass) spread over a large enough area to contain many territories, where the size of those territories depends strongly on habitat type. This understanding reflects a subtle, but significant, change in our understanding from a decade ago, when we recognized the importance of habitat, but did not fully appreciate the importance of prey as a habitat component in defining where tigers will persist. Given sufficient prey and an absence of persecution, tigers are remarkably catholic in their habitat requirements.

In addition to prey and habitat, tigers need to be free from persecution to thrive. Setting tiger priorities requires not only an examination of the biological factors promoting tiger success (e.g. prey, habitat), but also the human factors determining their fate, notably threats and the off-setting conservation measures. Tigers today require not only our forbearance to leave their homes and food supplies intact, but also the willingness of people to live with them and all that entails economically, socially, and spiritually.

Thus, securing existing breeding populations requires 1) identifying breeding populations and 2) the conditions that will support them in major habitat types and regions within the currently occupied range, then 3) working in those areas with interested people to create the supporting conditions tigers require—prey, habitat, freedom from persecution—so that tigers will continue to act as a wild species in Asia. It is a tall order, but the necessary work for the next ten years of tiger conservation.

6.2 Classifying Tiger Conservation Landscapes

6.2.1 Information for classifying TCLs

The conditions known for successful tiger conservation suggest five metrics for categorizing and prioritizing TCLs, namely:

1 - status of tiger populations (size, breeding status);

2 - status of prey populations (prey biomass, diversity relative to potential, assessment of threat to prey);

3 - habitat area (total area scaled by habitat-specific home range, number of full home range sized blocks, potential for connectivity);

4 - threat from persecution (assessment of threats, direct and indirect); and

5 - conservation measures (assessment of current and future conservation work).

In many cases, we will be hampered by lack of information about even the most basic metrics of tiger conservation. However we have through the current exercise assembled several indices to select from to help us in our task (see Chapter 2). These are detailed in Table 6.1.

Potential	*Data source*
Tiger population size	TCU questionnaire, categorical assessment
Breeding status	TCU questionnaire, yes/no/don't know assessment; also Tiger Point Database, same assessment
Prey biomass	Limited information from TCU questionnaire
Prey diversity	Limited information from TCU questionnaire
Threat to prey	TCU questionnaire: 5S type assessment
Relative area	Calculation from land cover classification; literature survey for approximate home range sizes by habitat type
Number of blocks larger than a home range	Calculation from land cover classification; literature survey for approximate home range sizes by habitat type
Potential for connectivity	Inter-TCL distances; intra-TCL patch size and distribution statistics
Area under protection	Calculated from TCL delineation and protected areas (WDPA) database; effectiveness for some protected areas is rated on the TCU questionnaire
Threats Measures	TCU questionnaire, list of measures with assessment of effectiveness
Conservation Measures	TCU questionnaire, list of measures with assessment of effectiveness

Table 6.1 Metrics of tiger conservation landscapes important for long term tiger conservation.

In addition each TCL is characterized by:

6 - biome (percentage areas of different potential habitat within the TCL based on the land cover analysis (Chapter 3), and calculated from the geographic information system (GIS)), and;

7 - bioregion (as defined in the first prioritization exercise in South and Southeast Asia, but extended now to include central Asia, China and Russia, and identified through GIS analysis).

Unfortunately, an important gap in our understanding revolves around the status of tiger prey. We lack systematic, range-wide information are on prey status and abundance. Thus, although we know that abundant prey is a key factor for determining tiger persistence across the range, we cannot include prey in this assessment of tiger conservation priorities. However we recommend that over the next 10 years, substantive effort be placed in developing information on the prey base in all TCLs.

For the other parameters, analysis shows that there is significant overlap between TCU 1.0 and the new TCLs (TCL 2.0), as described in the Chapter 4. New TCLs for which no questionnaire data are available, either because of lack of overlap, lack of response from the field, or simply ignorance, are rated as "Insufficient information for prioritization."

6.2.2 Class definitions for Tiger Conservation Landscapes

In TCU 1.0, TCUs were ranked within major habitat types and bioregions, such that the highest ranking (most important TCUs) were scored as Level I-globally important, important second tier TCUs as Level II-regionally important, and third tier TCUs as Level III-locally important. To determine these levels, TCUs were scored by measures of habitat area, configuration, threat and population status; the three highest ranking TCUs in each ecogeographic unit became Level I, the next Level II, etc. This model has been replicated elsewhere (e.g. Sanderson et al. 2002).

The problem with this kind of scoring system is that it does not clearly separate relative priorities, for example in a portfolio, from the "absolute" measure of how much a given landscape contributes to tiger conservation. A highly ranked area might be highly ranked because it is really good for tigers or because it is just the best there is within an ecoregional context. Only a close reading will distinguish the two.

In TCL 2.0 we chose a new way to rank our new TCLs: to first classify tiger conservation landscapes into distinct classes related to their current status and probability of reaching our goals for tiger conservation over the next decade, then to prioritize individual units to ensure representation across biomes and bioregions for tigers across the range. Classification provides an absolute metric of contributions of a landscape to tiger conservation; prioritization provides the relative value of a given area to meeting conservation and representation goals.

To this end, we propose that a Class I TCL be defined as a "success" for tiger conservation. For reasons explored elsewhere in this report, we define "success" as a known and secured breeding population of tigers in areas large enough for a substantive population. That is, a Class I TCL should possess:

1) a known breeding population;

2) with a sufficient prey base; and

3) sufficient habitat area (enough for 100+ tigers), scaled by habitat type; which is

4) under little or no threat, either because the threat levels are low or have been mitigated by conservation; and

5) conservation measures are in place, both locally and nationally, to ensure its long term conservation.

Class definitions are conditional in that all conditions must be met all for a landscape to be assigned to Class I. Conditional definitions make it clear to us, and to the world, what tigers need to persist.

Providing Class definitions also enables us to set clear and measurable goals. For example, investors in tiger conservation may chose to work to conserve at least three Class I TCLs in all parts of the tiger's current range.

In the new assessment, "lower" class TCLs are those that have potential to reach Class I status, but need more conservation effort to reach that status. Class II TCLs are TCLs that have the potential to secure a breeding population through conservation efforts in the next 10 years. Class II TCLs will typically be places where there is sufficient habitat, but where threats are reducing tiger populations, prey populations or both, such that conservation measures, if implemented with vigor and dedication, could protect populations and allow the TCL to recover to Class I status over the next 10 years.

Class III TCLs will require even more effort and longer time horizons, perhaps because there is insufficient habitat, the prey bases are too diminished to recover within the next ten years, or there is a lack of commitment to tiger conservation by local people and government in that TCL. Thus though important, their conservation will likely take a sustained effort of more than 10 years to rebuild habitat and connectivity to the required state.

Finally there will be TCLs where we lack enough information to credibly distinguish what class of TCL they are; these areas with insufficient information are marked as Class IV. Providing the required information could immediately reclassify these TCLs into a higher class type. Table 6.2 summarizes the proposed definitions of the different TCL Classes if adequate data on all criteria were available. Box 6.1 shows the operationalized definitions given the limitations of the current databases.

Table 6.2 represents a summary of class definitions; operationalizing these definitions, we need to reflect the data we have from the questionnaires, point data and geographic information system analysis to make these distinctions. These operational definitions, in terms of specific data items, are provided in Box 6.1, Data Requirements for TCL Classes.

6.2.3 Data Limitations on Tiger Conservation Landscape Classification

As discussed in Chapter 2, we lack systematic information on prey status across the range, so though we recognize the importance of prey in predicting future tiger persistence, we are unable to incorporate this information into the classification or prioritiza-

	Population Status*	Prey Population*	Habitat Area	Threats to tigers	Conservation Measures
Class I TCL	Scientifically estimated populations ≥100 tigers, and evidence of breeding	Evidence of stable and diverse prey populations	Enough inter-connected habitat for 100 female tiger home range equivalents, scaled by habitat type	Little to none, either because of lack of threat or conservation	Effective conservation measures in place, active enforcement, likely some protection
Class II TCL	Populations ≥50 tigers	A basis for prey populations to rise, but not currently sufficient	Enough inter-connected habitat for 50 tiger home range equivalents	Threats potentially can be mitigated in the next 10 years	Basis for conservation in place, but insufficient effort
Class III TCL	Some tigers	Prey non-existent or so low that 10 years or more is required for recovery	Less than 50 tiger home range equivalents of habitat	Threats exist and probably can not be sufficiently mitigated in the next 10 years	Need to build the basis (legal, actual) for conservation
Class IV TCL	Insufficient information on three or more conditions				

Table 6.2 Proposed definitions for TCL Classes (I, II, III and IV)[1]. *Note: Insufficient data exists to systematically evaluate TCLs with respoect to these criteria across the tiger's current range.*

Box 6.1 Data Requirements for TCL Classes

Class I Requirement

A Class I TCL meets all of the following criteria:

1) Habitat Area: Total habitat ≥ minimum area to support 100 tigers, scaled by habitat type or documented evidence of a population ≥ 100 tigers.

2) Breeding: Must have evidence of breeding. (Must have questionnaire or point data.)

3) Threats: Lower 50% of range of threat level (range normalized to a 0–1 range). Lower range of threat level is equivalent to lower level of threat.

4) Conservation Effectiveness: Upper 75% of range (range normalized to 0–1 range), meaning better conservation effectiveness. (That is, 25th percentile and above compared with all conservation scores)

Class II Requirement

A Class II TCL meets all of the following criteria:

1) Habitat area: Total habitat in TCL ≥ minimum area to support 50 tigers, scaled by habitat type or documented evidence of 50 tigers

2) Threats: Lower 75% of range of threat level (range normalized to a 0–1 range). Lower range of threat level is equivalent to lower level of threat.

Class III Requirement

A Class III TCL meets all of the following criteria:

1) All remaining TCLs for which some information on threats and conservation measures is available, but not classified as Class I or II.

Class IV Requirement

A Class IV TCL meets all of the following criteria:

1) All remaining TCLs, not classified as Class I, II or III. (i.e. Sufficient data on threats and conservation effectiveness are not available to this analysis.)

[1]See Box 5.1 for operationalized definitions given current databases

tions reported here. Similarly though the scientific assessment of tiger populations has advanced considerably over the last 8 years, we lack sufficient information to apply the population size criteria consistently across the entire range.

Many TCLs span multiple biomes and/or regions, and that different portions of the same TCL may have different classifications and/or prioritizations in different biomes and bioregions. Only portions of TCLs with enough potential habitat in a given biome and bioregion were classified and prioritized as potentially representing that biome.

6.3 Prioritizing Tiger Conservation Landscapes

6.3.1 Information for prioritizing Tiger Conservation Landscapes

Classification provides a measure of the current status and potential of each landscape to contribute to tiger conservation. However it is also important to consider TCLs in sets that ensure portfolio goals of representation, redundancy and resilience. As in TCU 1.0, we believe it is critical that we conserve tigers in all the different kinds of ecological settings where they occur. Tigers are extraordinary animals, with a remarkable ability to survive in habitats as different as the boreal forests of Russia and the dry tropical forests of India. Into the future, we need to ensure that "tigerness"—the qualities of tigers in the all these different ecosystems—is conserved along with tigers as wild species. This principle has been adopted in other species based prioritization exercises (e.g. jaguars, Sanderson et al. 2002).

In the context of conservation priority-setting, we represent these distinctions through an ecogeographic context, defined by geographic surrogates for important distinctions in tiger biology. For this exercise we are using a combination of biomes (as defined in Olson et al. 2001) and bioregions, as per the TCU 1.0, though now extended to cover all of the tiger's historical range. TCLs in this analysis were prioritized such that priority areas in each biome and each bioregion were identified. We suggest that goals for tiger conservation also be expressed in an ecogeographic context; for example, working toward multiple Class I TCLs in each biome by bioregion combination.

We based our ecological criteria for tiger conservation on the principles of representation, redundancy, and resistance. Conservation theory and practice suggests that these principles are necessary to conserve species in the wild. For tigers, we seek to sustain and improve TCL representation in each major habitat type (representation), secure one large or several smaller TCLs in each major habitat (redundancy), and prioritize those TCLs that have potential for tiger populations to resist disturbance events.

We prioritized the TCLs based on two primary data inputs: (1) TCL Class ranking and (2) the total habitat area within the TCL. We used the TCL Class rankings as a starting point to prioritize, and then used the total habitat area within the TCLs to identify which TCL should be elevated to a higher priority to meet ecogeographic representation of TCLs. We felt that these two information sources would provide a transparent and simple method in which to prioritize the TCLs, with the assumption that tiger populations in larger habitat areas would be more resistant to future disturbances.

We established four priority levels for prioritizing TCL:

- o Global priorities for tiger conservation
- o Regional priorities for tiger conservation
- o Long-term priorities for tiger conservation
- o Insufficient information to prioritize

6.3.2 Prioritization of Tiger Conservation Landscapes

We used the following steps in sequential order to assess and prioritize each TCL to meet our goals of representation, redundancy, and resistance.

Step 1. All Class I TCLs are assigned Global Priority. The Class I TCLs represent the best places to conserve tigers based on ecological, conservation, and threat, and therefore will form the basis for any global tiger conservation strategy. They are the backbone of any long-term strategy to save tigers. As such, all Class I TCLs were identified as Global priority TCLs.

Step 2. Assign to Global Priority the largest Class II TCL in any biome which does not have representation. This step is to ensure representation of all major habitat types as tiger priorities, so as to capture the unique evolutionary history of tigers across their historic range.

Step 3. Within the two major habitat types, tropical moist and tropical dry forest (which include >75% of the count of TCLs), assign to Global Priority the largest Class II TCLs so that there are at least 3 Global Priority TCLs in each bioregion. This step is meant to ensure redundancy of tiger populations in the most important habitat types in which they are still found. Unfortunately there are not enough TCLs in other biomes to allow this step to be more broadly applied.

Step 4. Assign to Regional Priority all remaining Class II TCLs. Class II TCLs have the potential to become Class I over the next 10 years with increased conservation investment. They are the next generation of landscapes for tiger conservation and in some biomes and bioregions, essential to filling out the tiger conservation portfolio. Many of these areas are of critical national and regional importance.

Step 5. Within the two major habitat types, tropical moist and tropical dry forest, assign to Regional Priority the largest Class III TCLs so that there are at least three Regional Priority TCLs in each bioregion. This step is meant to ensure redundancy of tiger populations in the most important habitat types in which they are still found. Again too few TCLs were found in other biomes to allow this step to be more broadly applied.

Step 6. Assign to Long-term Priority all remaining Class III TCLs. Class III landscapes will take conservation effort above and beyond the next decade to bring them back to Class I status. However some of these landscapes have great national and local importance and our deserving of continued attention to national and local conservation authorities and organizations.

Step 7. Assign to Insufficient Information to Prioritize to all Class IV TCLs. Class IV landscapes suffer from lack of information, usually about ongoing conservation effort and the level of threat within the landscape. Adding this information to the database will enable us to place these landscapes within the classification and prioritization taxonomy.

6.3.3 Prioritization of Survey and Restoration Landscapes

As with the TCL prioritization, we prioritized both the Survey and Restoration Landscapes based on the concepts of representation, redundancy, and resistance. For each bioregion we identified as "priority" the TCLs in the top 20% based on total habitat area.

6.4 Results: Classes and Priorities of Tiger Conservation Landscapes

6.4.1 Classes of Tiger Conservation Landscapes

Of the 76 Tiger Conservation Landscapes, 16 were designated Class I, 15 as Class II, 23 as Class III and 22 as Class IV (Figures 6.1 and 6.2). While only 21% of the TCLs were placed in Class I, the greater average size of these areas mans that over 77% of the total area of delineated as TCLs is categorized as Class I—breeding tiger populations in large areas with some conservation and relatively lower threats. Class II TCLs make up approximately 10% of TCLs by area—these landscapes have the potential to be recovered over the next 10 years, given more conservation effort. The remaining Class III TCLs will take longer to recover—they comprise 4.3% of the total TCL area; and 8.6% of TCLs need more information in order to classify (Class IV).

The distribution of TCLs across biomes is uneven (Tables 6.3 and 6.4). TCLs are heavily weighted toward tropical moist forests, and tropical biome types more generally, both in terms of number and area. (These may be due at least in part to the fact that these are the most common biomes in South and SE Asia).

Areas and numbers of distinct TCLs are not always parallel. For example, there is a large amount of TCL area in temperate broadleaf and mixed forests, but all of this area comes from two very large TCLs: the Russian Far East and the Northern Forest Complex–Namdapha–Royal Minas landscape.

At least one, representative Class I TCLs, is found in every biome except Mangroves (Table 6.4), but the number varies considerably by biome, from 16 within the tropical moist forests, to only one for several of the temperate biome types. The distribution of Class II, III, and IV TCLs shows similar distributions, heavily weighted toward tropical biome types. Recall that for a TCL to be "representative" of a given biome or bioregion

	TCL Class				
Biomes	**I**	**II**	**III**	**IV**	**Total**
Tropical & Subtropical Moist Broadleaf Forests	507,044	77,104	39,570	77,273	700,991
Tropical & Subtropical Dry Broadleaf Forests	55,656	37,798	4,650	24,495	122,599
Tropical & Subtropical Coniferous Forests	4,249	516	76	14	4,855
Tropical & Subtropical Grasslands, Savannas & Shrublands	2,752	2,755	1,758		7,265
Temperate Broadleaf & Mixed Forests	251,339			177	251,516
Boreal Forests/Taiga	72,208				72,208
Temperate Conifer Forests	5,130				5,130
Flooded Grasslands & Savannas	17,292			1,138	18,430
Montane Grasslands & Shrublands	1,525				1,525
Mangroves	67	19	5,265	98	5,449
Total	917,262	118,192	51,320	103,195	1,189,969

Table 6.3 Distribution of Tiger Conservation Landscape area (km^2) by Biome and TCL Class.

	TCL Class				
Biomes	**I**	**II**	**III**	**IV**	**Total**
Tropical & Subtropical Moist Broadleaf Forests	16	10	20	14	60
Tropical & Subtropical Dry Broadleaf Forests	9	5	4	11	29
Tropical & Subtropical Coniferous Forests	3	2	0*	0*	5
Tropical & Subtropical Grasslands, Savannas & Shrublands	2	3	1		6
Temperate Broadleaf & Mixed Forests	2			0*	2
Temperate Conifer Forests	1				1
Boreal Forests/Taiga	1				1
Flooded Grasslands & Savannas	1			1	2
Montane Grasslands & Shrublands	1				1
Mangroves	0*	0*	1	0*	1
Total	36	20	26	26	108

Table 6.4 Distribution of Representative TCLs by Biome and TCL Class. many TCLs cross biome boundaries so are counted more than once.

	TCL Class				
Bioregion	**I**	**II**	**III**	**IV**	**Total**
Indian Subcontinent	133,745	19,242	17,379	64,292	234,658
Indochina	430,745	85,233	12,981	11,436	540,395
Peninsular Malaysia	47,631		7,752		55,383
Sumatra	35,267	13,716	11,103	26,152	86,238
Russian Far East	238,174				238,174
China-Korea	31,700	0	4	1,315	33,019
Total	917,262	118,191	49,219	103,195	1,187,867

Table 6.5 Distribution of Tiger Conservation Landscape area (km^2) by Bioregion and TCL Class.

type, it must have enough area for at least five tigers defined in a habitat-specific way (Chapter 4).

Class I TCLs are also found in all bioregions across the current range, with the least areas in Sumatra, China-Korea, and Peninsular Malaysia (Table 6.5). Sumatra has additional landscape areas classified in lower classes.

Survey and Restoration Landscapes were not classified.

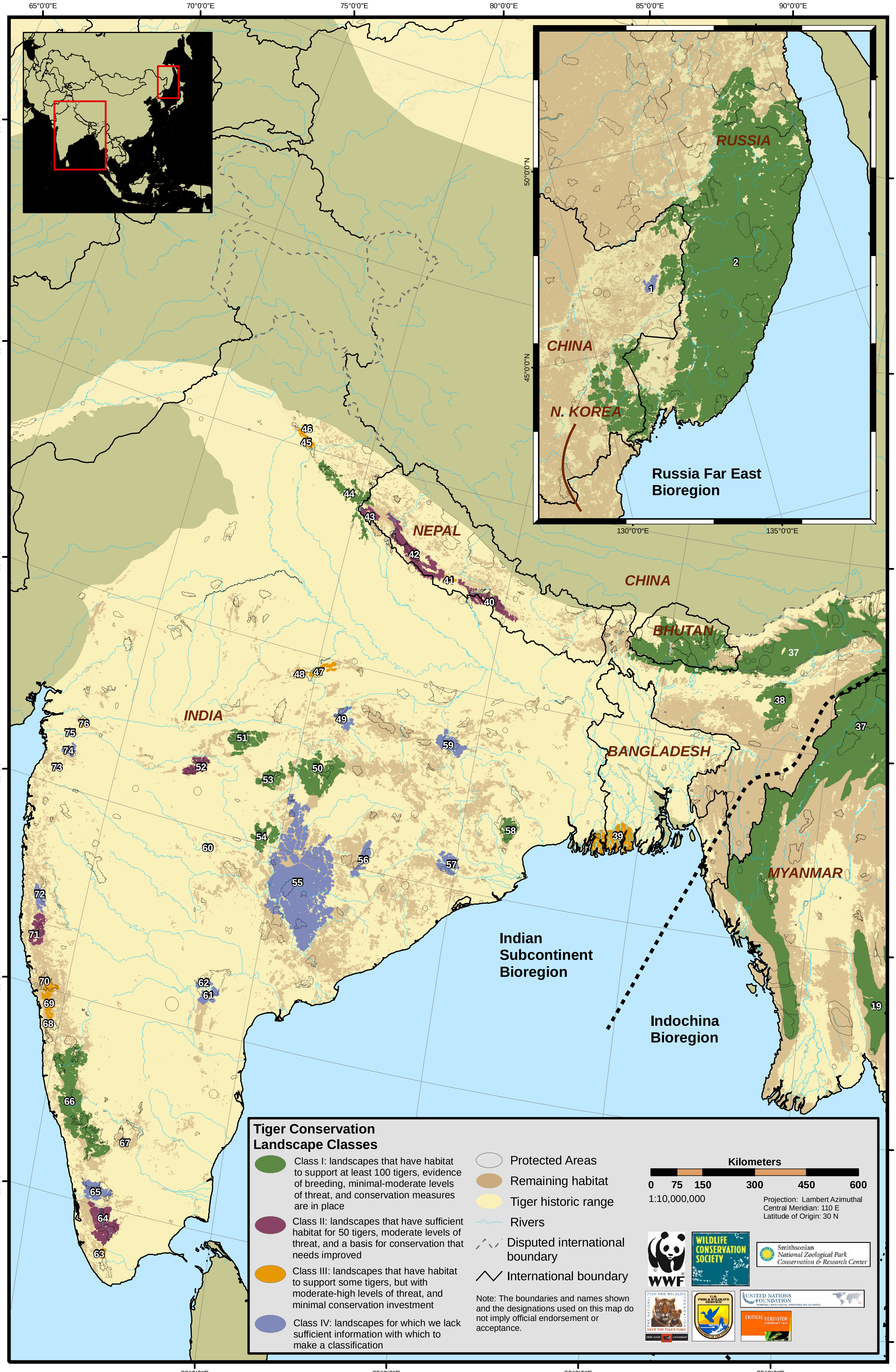
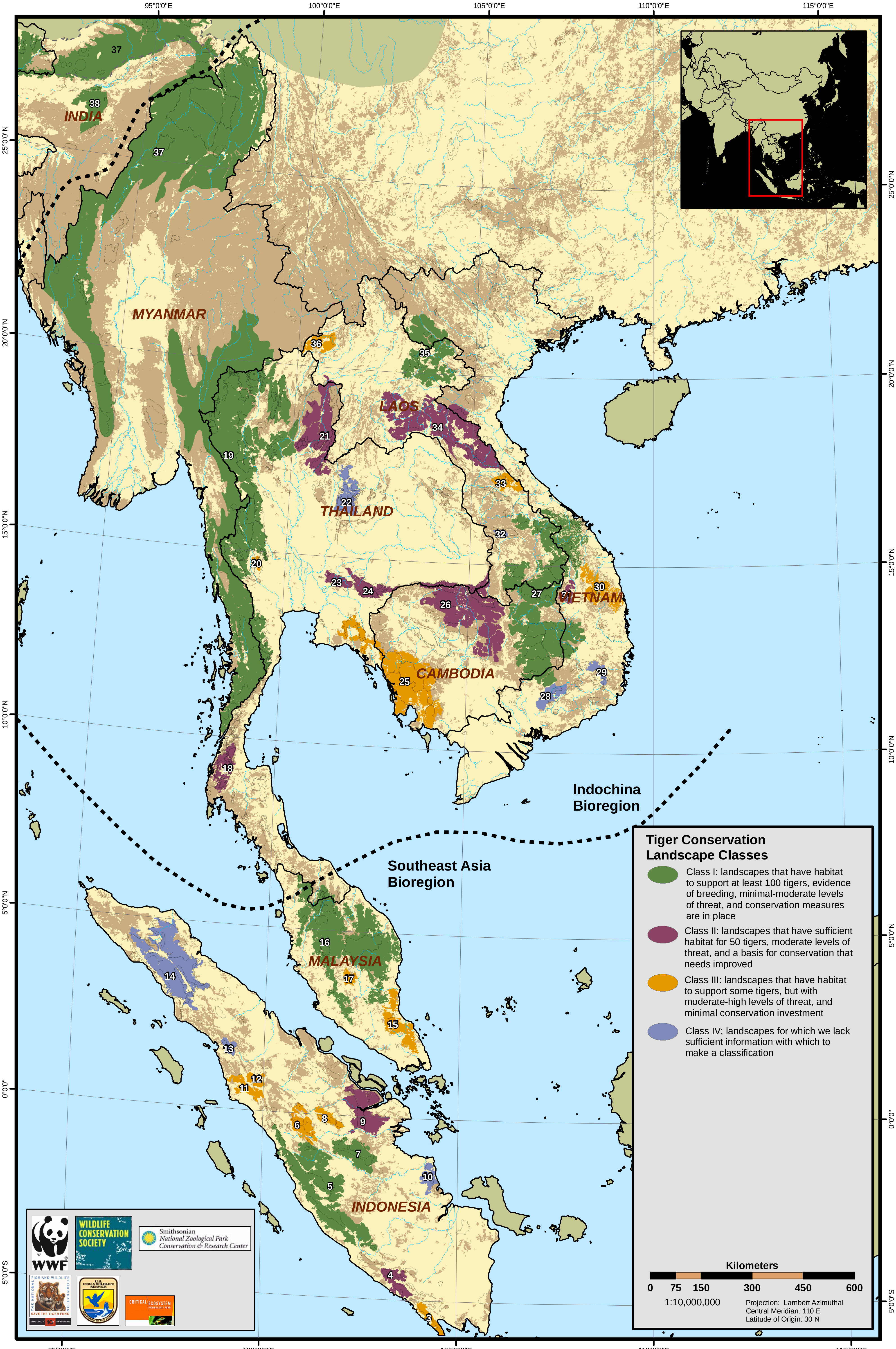
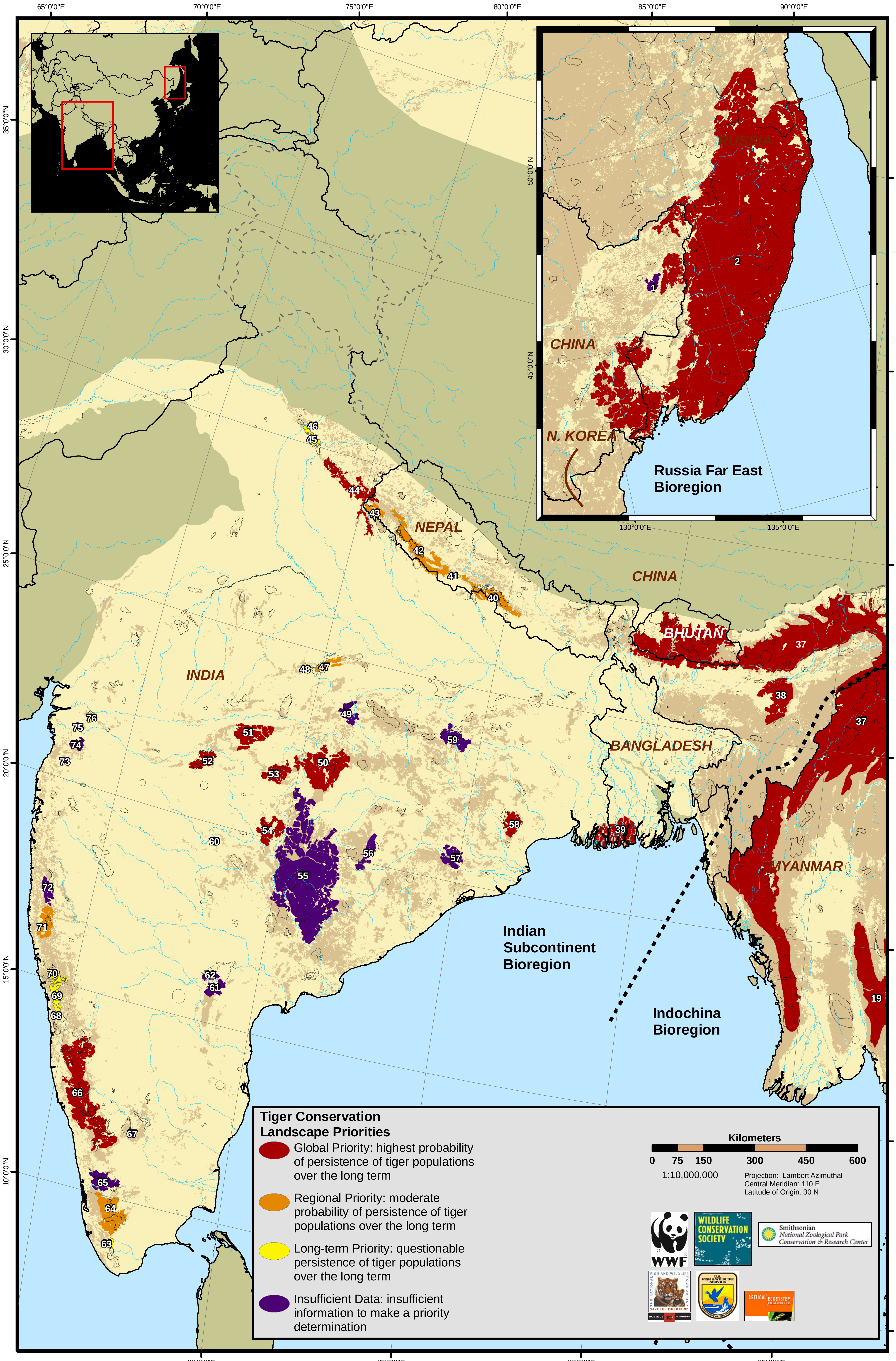


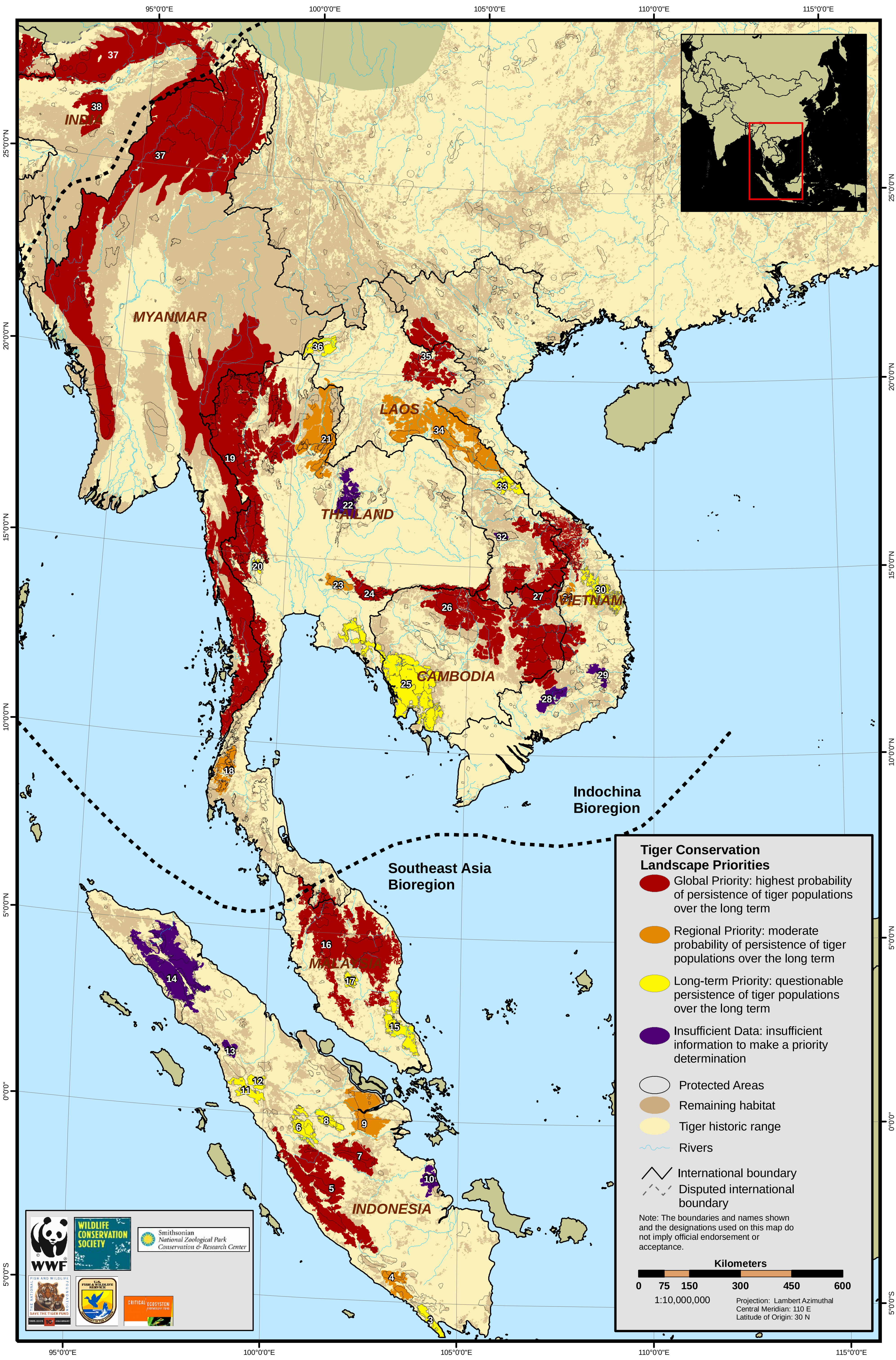
Figure 6.1 Tiger landscape classification (Indian subcontinent, China and Russia)



INDIA
MYANMAR
THAILAND
LAOS
CAMBODIA
VIETNAM
MALAYSIA
INDONESIA
Indochina Bioregion
Southeast Asia Bioregion
Tiger Conservation Landscape Classes
Class I: landscapes that have habitat to support at least 100 tigers, evidence of breeding, minimal-moderate levels of threat, and conservation measures are in place
Class II: landscapes that have sufficient habitat for 50 tigers, moderate levels of threat, and a basis for conservation that needs improved
Class III: landscapes that have habitat to support some tigers, but with moderate-high levels of threat, and minimal conservation investment
Class IV: landscapes for which we lack sufficient information with which to make a classification
Kilometers
0 75 150 300 450 600
1:10,000,000
Projection: Lambert Azimuthal
Central Meridian: 110 E
Latitude of Origin: 30 N
WWF
WILDLIFE CONSERVATION SOCIETY
Smithsonian National Zoological Park Conservation & Research Center
SAVE THE TIGER FUND
CRITICAL ECOSYSTEM



Russia Far East Bioregion
RUSSIA
CHINA
N. KOREA
NEPAL
CHINA
BHUTAN
INDIA
BANGLADESH
MYANMAR
Indian Subcontinent Bioregion
Indochina Bioregion
Tiger Conservation Landscape Priorities
Global Priority: highest probability of persistence of tiger populations over the long term
Regional Priority: moderate probability of persistence of tiger populations over the long term
Long-term Priority: questionable persistence of tiger populations over the long term
Insufficient Data: insufficient information to make a priority determination
Kilometers
0 75 150 300 450 600
1:10,000,000
Projection: Lambert Azimuthal
Central Meridian: 110 E
Latitude of Origin: 30 N
WWF
WILDLIFE CONSERVATION SOCIETY
Smithsonian National Zoological Park Conservation & Research Center
SAVE THE TIGER FUND
CRITICAL ECOSYSTEM



Tiger Conservation Landscape Priorities
Global Priority: highest probability of persistence of tiger populations over the long term
Regional Priority: moderate probability of persistence of tiger populations over the long term
Long-term Priority: questionable persistence of tiger populations over the long term
Insufficient Data: insufficient information to make a priority determination
Protected Areas
Remaining habitat
Tiger historic range
Rivers
International boundary
Disputed international boundary
Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance.
Kilometers
0 75 150 300 450 600
1:10,000,000
Projection: Lambert Azimuthal
Central Meridian: 110 E
Latitude of Origin: 30 N
INDIA
MYANMAR
LAOS
THAILAND
VIETNAM
CAMBODIA
MALAYSIA
INDONESIA
Indochina Bioregion
Southeast Asia Bioregion
95°0'0"E
100°0'0"E
105°0'0"E
110°0'0"E
115°0'0"E
25°0'0"N
20°0'0"N
15°0'0"N
10°0'0"N
5°0'0"N
0°0'0"
5°0'0"S
WWF
WILDLIFE CONSERVATION SOCIETY
Smithsonian National Zoological Park Conservation & Research Center
SAVE THE TIGER FUND
U.S. FISH & WILDLIFE SERVICE
CRITICAL ECOSYSTEM

6.4.2 Priorities for Tiger Conservation Landscapes

Table 6.6 lists the priority Tiger Conservation Landscapes by biome across the current range. In total, 20 TCLs were identified as "Global Priorities for Tiger Conservation" representing all the major biomes and bioregions where tigers occur. The majority of these areas are Class I TCLs. The Sundarbans, a Class III TCL, was assigned to the Global Priority category to ensure representation of Mangroves. To assure redundancy in Tropical Dry Forest, we also assigned Melghat in the Indian subcontinent, and Cambodian Northern Plains and Thap Lan–Pang Sida in Indochina to Global Priority status. (Figures 6.3 and 6.4—map of all the TCL priorities for Indian subcontinent, China and Russia; and mainland Southeast Asia and Sumatra).

Thirteen TCLs were identified as "Regional Priorities for Tiger Conservation." These areas represent four tropical biome types and therefore only occur in the tropical bioregions of the Indian subcontinent, Indochina, and Sumatra. The majority of these are Class II TCLs. Panna East from the Indian Subcontinent was assigned to Global Priority to meet the redundancy criteria in Tropical Dry Forests. Insufficient TCLs were identified in other biomes to provide "regional" priorities across the range.

Twenty-one TCLs were identified as "Long-term Priorities for Tiger Conservation" and 22 TCLs lacked sufficient information to prioritize. Adding conservation and threats information for these TCLs would enable them to be classified and prioritized with the others.

Critically important for global tiger conservation are two areas that represent no less than seven biomes between them: the Russian Far East and the Northern Forest Complex-Namdapha-Royal Manas. When combined with Corbett-Sonanadi, Tenasserims, Southern Annamites, and the Sundarbans, these six TCLs capture the largest areas of habitat within all the major biomes for tigers across the range. All these areas have breeding populations and some conservation measures in place.

For the Restoration Landscapes within the current range, we identified 3 priorities in the Indian subcontinent; 5 in Indochina; and 2 in Southeast Asia. There were no Restoration Landscapes in the Russia Far East bioregion (see Figure 6.5).

In comparison to the Restoration Landscapes, there were many more Survey Landscapes throughout the tiger's range. Many of these areas are small habitat fragments close to TCLs. We identified 73 survey priorities in the Indian Subcontinent Bioregion; 20 survey priorities in the Indochina bioregion; 5 in Southeast Asia; and 2 in the Russia Far East Bioregion (Figure 6.5).

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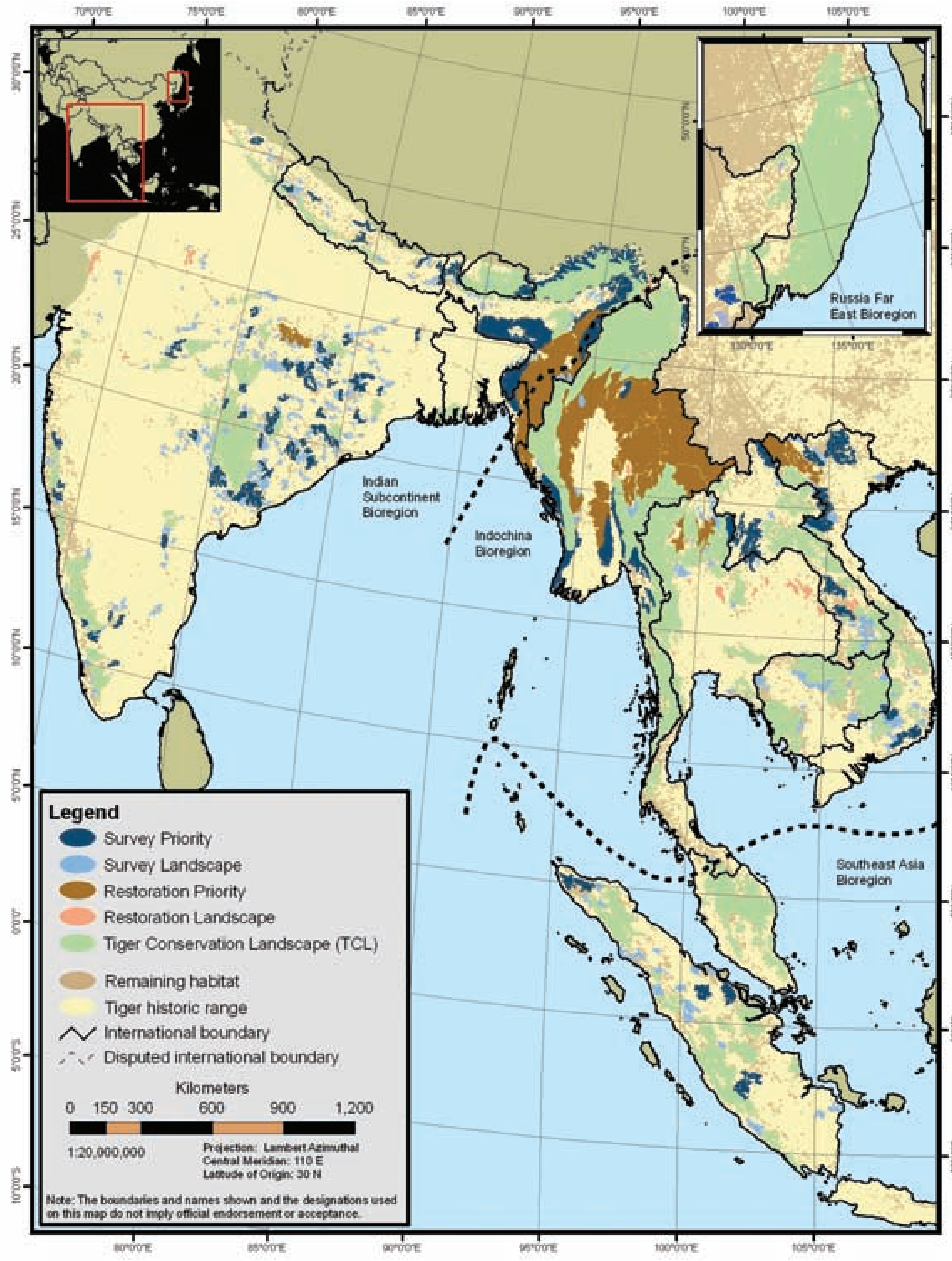

Figure 6.5 Survey and Restoration Area Prioritization

BIOME	TCL 2.0 ID	TCU 1.0 ID	TCL Name	BIOREGION	Class	TCL Area in Biome x Bioregion (km2)	Total TCL Area (km2)	Breeding	Threats Score	Con-servation Effective-ness Score
Global Priorities for Tiger Conservation										
Tropical & Subtropical Moist Broadleaf Forests										
	66	IS055	Western Ghats: Bandipur - Khudrenukh – Bhadra	Indian Subcontinent	I	18,801	18,973	1	136	60
	50	IS031	Kanha – Phen	Indian Subcontinent	I	10,598	10,598	1	230	35
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indian Subcontinent	I	8,973	237,820	1	115	35
	38	IS016	Kaziranga - Garampani	Indian Subcontinent	I	7,514	7,514	1	118	34
	51	IS028	Pachmarhi - Satpura - Bori	Indian Subcontinent	I	4,924	4,924	1	273	33
	58	IS039	Simlipal	Indian Subcontinent	I	2,364	2,412	1	199	38
	44	IS001	Corbett - Sonanadi	Indian Subcontinent	I	1,681	5,996	1	106	56
	53	IS031	Pench	Indian Subcontinent	I	1,566	2,918	1	230	35
	19	IC014	Tenasserims	Indochina	I	160,288	162,726	1	206	23
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indochina	I	149,420	237,820	1	115	35
	35	IC035	Nam Et Phou Loey	Indochina	I	17,866	17,866	1	198	35
	27	IC055	Southern Annamites	Indochina	I	13,829	61,252	1	285	29
	16	SA001	Taman Negara - Belum	Indochina	I	1,418	49,181	1	2	36
	16	SA001	Taman Negara - Belum	Peninsular Malaysia	I	47,761	49,181	1	2	36
	5	SA020	Kerinci Seblat	Sumatra	I	27,432	28,162	1	69	18
	7	SA020	Bukit Tigapuluh Landscape	Sumatra	I	7,106	7,106	1	69	18
Tropical & Subtropical Dry Broadleaf Forests										
	54	IS044	Andhari - Tadoba	Indian Subcontinent	I	3,680	3,680	1	123	45
	52	IS028	Melghat	Indian Subcontinent	II	2,398	2,398	1	273	33
	53	IS031	Pench	Indian Subcontinent	I	1,352	2,918	1	230	35
	66	IS055	Western Ghats: Bandipur - Khudrenukh - Bhadra	Indian Subcontinent	I	172	18,973	1	136	60
	58	IS039	Simlipal	Indian Subcontinent	I	48	2,412	1	199	38
	27	IC055	Southern-Central Annamites	Indochina	I	47,423	61,252	1	285	29
	26	IC064	Cambodian Northern Plains	Indochina	II	26,835	26,835	0	294	26
	24	IC064	Thap Lan - Pang Sida	Indochina	II	4,445	4,445	0	294	26

Figure 6.6 Priorities of Tiger Conservation Landscapes

BIOME	TCL 2.0 ID	TCU 1.0 ID	TCL Name	BIOREGION	Class	TCL Area in Biome x Bioregion (km2)	Total TCL Area (km2)	Breeding	Threats Score	Con-servation Effective-ness Score
	19	IC014	Tenasserims	Indochina	I	2,385	162,726	1	206	23
Tropical & Subtropical Coniferous Forests										
	44	IS001	Corbett - Sonanadi	Indian Subcontinent	I	3,148	5,996	1	106	56
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indian Subcontinent	I	279	237,820	1	115	35
	5	SA020	Kerinci Seblat	Sumatra	I	729	28,162	1	69	18
Tropical & Subtropical Grasslands, Savannas & Shrublands										
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indian Subcontinent	I	1,567	237,820	1	115	35
	44	IS001	Corbett - Sonanadi	Indian Subcontinent	I	1,167	5,996	1	106	56
Temperate Broadleaf & Mixed Forests										
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indian Subcontinent	I	60,991	237,820	1	115	35
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indochina	I	10,308	237,820	1	115	35
	2	none	Russian Far East - China	Russian Far East	I	156,272	269,983	1	138	56
	2	none	Russian Far East - China	China-Korea	I	25,116	269,983	1	138	56
Temperate Conifer Forests										
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indian Subcontinent	I	4,891	237,820	1	115	35
Boreal Forests/Taiga										
	2	none	Russian Far East - China	Russian Far East	I	72,207	269,983	1	138	56
Flooded Grasslands & Savannas										
	2	none	Russian Far East - China	Russian Far East	I	9,973	269,983	1	138	56
	2	none	Russian Far East - China	China-Korea	I	6,288	269,983	1	138	56
Montane Grasslands & Shrublands										
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indian Subcontinent	I	55	237,820	1	115	35
	37	IC001	Northern Forest Complex - Namdapha - Royal Manas	Indochina	I	1,332	237,820	1	115	35
Mangroves										
	39	IS018	Sundarbans	Indian Subcontinent	III	5,265	5,304	1	247	27

Figure 6.6 (*continued*) Priorities of Tiger Conservation Landscapes

BIOME		TCL 2.0 ID	TCU 1.0 ID	TCL Name	BIOREGION	**Class**	TCL Area in Biome x Bioregion (km2)	Total TCL Area (km2)
Regional Priorities for Tiger Conservation								
Tropical & Subtropical Moist Broadleaf Forests								
64	IS059 Periyar - Megamala	Indian Subcontinent	**II**	5,978	5,978	1	50	37
42	IS004 Royal Bardia	Indian Subcontinent	**II**	4,655	6,777	1	59	52
71	IS055 Radhanagari	Indian Subcontinent	**II**	2,945	2,945	1	136	60
40	IS006 Royal Chitwan	Indian Subcontinent	**II**	2,523	4,055	1	11	78
34	IC040 Northern Annamites	Indochina	**II**	28,826	28,826	0	241	14
21	IC022 Phu Miang - Phu Thong	Indochina	**II**	16,273	16,273	0	206	23
18	IC014 Khlong Saeng	Indochina	**II**	4,814	4,816	1	206	23
9	SA022 Kualar Kampar-Kerumutan	Sumatra	**II**	9,833	9,835	1	119	37
4	SA031 Bukit Balai Rejang - Selatan	Sumatra	**II**	3,883	3,884	1	260	46
Tropical & Subtropical Dry Broadleaf Forests								
23	IC063 Khao Yai	Indochina	**II**	2,253	2,253	0	276	38
31	IC055 Yokdon	Indochina	**II**	1,787	1,787	0	285	29
47	IS025 Panna East	Indian Subcontinent	**III**	1,390	1,390	1	156	44
Tropical & Subtropical Coniferous Forests								
42	IS004 Royal Bardia	Indian Subcontinent	**II**	524	6,777	1	59	52
40	IS006 Royal Chitwan	Indian Subcontinent	**II**	34	4,055	1	11	78
Tropical & Subtropical Grasslands, Savannas & Shrublands								
42	IS004 Royal Bardia	Indian Subcontinent	**II**	1,598	6,777	1	59	52
40	IS006 Royal Chitwan	Indian Subcontinent	**II**	1,497	4,055	1	11	78
43	IS002 Royal Suklaphanta	Indian Subcontinent	**II**	1,144	1,144	1	106	56
Long Term Priorities for Tiger Conservation								
Tropical & Subtropical Moist Broadleaf Forests								
69	IS055 Dandeli - Anshi	Indian Subcontinent	**III**	2,316	2,316	1	136	60
45	IS001 Rajaji Minor	Indian Subcontinent	**III**	1,044	1,044	1	127	48
63	IS059 Shendurney	Indian Subcontinent	**III**	603	603	1	50	37
70	IS055 Dandeli North	Indian Subcontinent	**III**	517	517	1	136	60
76	IS028 Shoolpaneswar	Indian Subcontinent	**III**	511	511	1	273	33

Figure 6.6 (*continued*) Priorities of Tiger Conservation Landscapes

BIOME		TCL 2.0 ID	TCU 1.0 ID	TCL Name	BIOREGION	**Class**	TCL Area in Biome x Bioregion (km2)	Total TCL Area (km2)
Regional Priorities for Tiger Conservation								
Tropical & Subtropical Moist Broadleaf Forests								
64	IS059 Periyar - Megamala	Indian Subcontinent	II	5,978	5,978	1	50	37
42	IS004 Royal Bardia	Indian Subcontinent	II	4,655	6,777	1	59	52
71	IS055 Radhanagari	Indian Subcontinent	II	2,945	2,945	1	136	60
40	IS006 Royal Chitwan	Indian Subcontinent	II	2,523	4,055	1	11	78
34	IC040 Northern Annamites	Indochina	II	28,826	28,826	0	241	14
21	IC022 Phu Miang - Phu Thong	Indochina	II	16,273	16,273	0	206	23
18	IC014 Khlong Saeng	Indochina	II	4,814	4,816	1	206	23
9	SA022 Kualar Kampar-Kerumutan	Sumatra	II	9,833	9,835	1	119	37
4	SA031 Bukit Balai Rejang - Selatan	Sumatra	II	3,883	3,884	1	260	46
Tropical & Subtropical Dry Broadleaf Forests								
23	IC063 Khao Yai	Indochina	II	2,253	2,253	0	276	38
31	IC055 Yokdon	Indochina	II	1,787	1,787	0	285	29
47	IS025 Panna East	Indian Subcontinent	III	1,390	1,390	1	156	44
Tropical & Subtropical Coniferous Forests								
42	IS004 Royal Bardia	Indian Subcontinent	II	524	6,777	1	59	52
40	IS006 Royal Chitwan	Indian Subcontinent	II	34	4,055	1	11	78
Tropical & Subtropical Grasslands, Savannas & Shrublands								
42	IS004 Royal Bardia	Indian Subcontinent	II	1,598	6,777	1	59	52
40	IS006 Royal Chitwan	Indian Subcontinent	II	1,497	4,055	1	11	78
43	IS002 Royal Suklaphanta	Indian Subcontinent	II	1,144	1,144	1	106	56
Long Term Priorities for Tiger Conservation								
Tropical & Subtropical Moist Broadleaf Forests								
69	IS055 Dandeli - Anshi	Indian Subcontinent	III	2,316	2,316	1	136	60
45	IS001 Rajaji Minor	Indian Subcontinent	III	1,044	1,044	1	127	48
63	IS059 Shendurney	Indian Subcontinent	III	603	603	1	50	37
70	IS055 Dandeli North	Indian Subcontinent	III	517	517	1	136	60
76	IS028 Shoolpaneswar	Indian Subcontinent	III	511	511	1	273	33

Figure 6.6 (*continued*) Priorities of Tiger Conservation Landscapes

BIOME			TCL 2.0 ID	TCU 1.0 ID	TCL Name	BIOREGION	**Class**	TCL Area in Biome x Bioregion (km2)	Total TCL Area (km2)
73	none	Mahabaleshwar Landscape - South	Indian Subcontinent	**IV**	344	344	0	no data	no data
67	IS056	Biligiri Range	Indian Subcontinent	**IV**	278	278	1	no data	no data
49	IS027	Bandhavgarh - Panpatha	Indian Subcontinent	**IV**	72	2,020	1	no data	no data
59	IS027	Palamau	Indian Subcontinent	**IV**	60	3,209	0	no data	no data
22	IC042	Phu Khieo	Indochina	**IV**	5,568	5,760	0	no data	no data
29	IC062	Bi Dup-Nui Ba	Indochina	**IV**	1,660	1,660	0	no data	no data
14	SA017	Gunug Leuser	Sumatra	**IV**	22,319	22,319	0	no data	no data
10	SA024	Berbak	Sumatra	**IV**	2,541	2,543	0	no data	no data
13	SA018	Sibologa	Sumatra	**IV**	1,292	1,292	0	no data	no data
Tropical & Subtropical Dry Broadleaf Forests									
55	IS046	Indravati	Indian Subcontinent	**IV**	9,251	44,238	0	no data	no data
59	IS027	Palamau	Indian Subcontinent	**IV**	3,149	3,209	0	no data	no data
56	IS047	Sunabeda-Udanti	Indian Subcontinent	**IV**	2,287	2,287	0	no data	no data
49	IS027	Bandhavgarh - Panpatha	Indian Subcontinent	**IV**	1,948	2,020	1	no data	no data
61	IS052	Nagarjunasagar South	Indian Subcontinent	**IV**	1,699	1,699	0	no data	no data
62	IS052	Nagarjunasagar North	Indian Subcontinent	**IV**	915	915	0	no data	no data
60	none	Painganga	Indian Subcontinent	**IV**	442	442	0	no data	no data
75	none	Mahabaleshwar Landscape - North	Indian Subcontinent	**IV**	406	406	0	no data	no data
28	IC062	Cat Tien	Indochina	**IV**	3,359	3,359	0	no data	no data
32	IC045	Xe Bang Nouan	Indochina	**IV**	657	657	0	no data	no data
22	IC042	Phu Khieo	Indochina	**IV**	192	5,760	0	no data	no data
Flooded Grasslands & Savannas									
1	none	Heilongjiang	China-Korea	**IV**	1,315	1,315	0	no data	no data

Figure 6.6 (*continued*) Priorities of Tiger Conservation Landscapes

6.5 Discussion

6.5.1 What is the state of the world's wild tigers?

In 2005, our best estimates conclude that tigers occupy only 7% of their historical range. Over the last 10 years estimates of tiger habitat in India, Indochina, and Southeast Asia have dropped over 40%. Strongholds for tigers remain, in large landscapes of intact habitat, anchored by protected areas, and identified as Global Priorities in this chapter, but these areas remain dependent on conservation investment. Tigers are a conservation dependent species. New investment is necessary to bring other areas back to be able to sustain adequate populations. At current levels of conservation effort, tigers may not go extinct in the next 10 years, but tigers risk becoming ecologically extinct in many of the diverse habitats where they live. New efforts could turn the tide for tigers in the next decade and launch a new trajectory for the tigers as a wild species.

	Number of Tiger Conservation Landscapes	Total TCL Area (km^2)	Median Size of TCL (km^2)
TCL Priority			
Global	20	924,791	9,056
Regional	13	89,963	3,970
Long-term	21	66,960	1,486
Insufficient data	22	103,197	1,691
Bioregion			
Indian Subcontinent	40	227,569	2,154
Indochina	20	540,758	5,288
Southeast Asia	15	145,285	3,884
Russian Far East	2	271,298	135,649

Table 6.7 Summary of Tiger Conservation Landscapes.

Our results show that the Indian subcontinent bioregion has the largest number of TCLs (40, of which 11 are of Global Priority). The Northern Forests of Nepal-India-Bhutan-Myanmar, Western and Eastern Ghats, Sundarbans, and Terai Arc set the foundation for tiger conservation across a diverse array of habitats in this bioregion. Yet, this bioregion also has the most questionable habitats, where we were unable to assess or determine if tigers still do, or can, persevere in small, isolated habitat patches.

The Indochina bioregion supports 20 TCLs, but these account for the largest total area (~540,000 km^2) among the four bioregions, primarily because they represent vast swathes along the mountain regions of Myanmar and Thailand (notably the Tennerassims) and the Annamite Mountains of Laos and Viet Nam. Six are Global Priorities. The large areas of dry forest mosaics in Cambodia are likely the best such forest habitats for tigers across its range. Unfortunately tigers have largely been extirpated from many of the lowlands within this bioregion, and restoring tigers to these areas will require a sustained, long-term effort.

The Southeast Asia bioregion harbors 15 TCLs, with three being Global Priorities. The latter are primarily in the montane regions, centered around Malaysia's Taman Negara National Park, and Sumatra's Kerinci National Park. In Sumatra's large Leuser ecosystem the status of tigers is unknown, but it overlaps with critical habitat for the orang-utan and Sumatran rhinoceros and has been designated as both a World Heritage Site and Man and Biosphere reserve, confirming the importance of this ecosystem to Sumatra's natural heritage. Bukit Barisan Selatan, representing the southern most outpost of the tiger's range, is facing mounting pressures from habitat destruction.

The Russia Far East bioregion is home for two TCLs, including the world's largest, which is 270,000 km^2. This TCL is primarily in Russia, but extends into Korea and northeast China, which has recently recorded tigers on its side of the border. Although this vast mixed temperate forest TCL has approximately 10% of its area under protection, the rest is also unprotected wilderness in which the tiger is still able to persist. However rapid changes due to privatization and leasing of this forest to timber industries darken the future of the Amur tiger.

6.5.2 Setting goals for tiger conservation

This chapter provides the information necessary to develop clear, objective, measurable, and broadly-based goals for tiger conservation. The classification system is designed as a measuring stick against which TCLs can be evaluated today and into the future. Ten years from now, how many Class I TCLs will still have breeding populations and enough habitat for 100 tigers? Ten years from now, how many Class II TCLs will have had sufficient conservation to bring them up to Class I levels? Ten years from now, how many Class IV TCLs will still be unknown to the tiger community at large?

We suggest that as part of a long-term strategy, the next decade should focus on ensuring tigers representation of tigers across all the major biomes where they occur. The TCLs marked as Global Priorities in Table 6.6 provide the palette of choices for investment by biome. Most of these areas have ongoing conservation efforts that need to be recognized, supported, and strengthened. Representation of "tigerness" is still possible but it requires a commitment to investment. Tigers remain dependent on our conservation success.

There are two large TCLs (the Russian Far East and the Northern Forest Complex-Namdapha-Royal Manas) where investment to maintain tigers will provide representation across many biomes. Add to these the Tennerassims, Southern Annamites and investment in the Corbett-Sonandi and other Terai Arc TCLs, and we have in place potential strongholds to anchor tiger conservation across the range.

Additional investments should be focused on bringing Class II TCLs, mainly marked as regional priorities for conservation, to the Class I levels. These areas, and to a lesser extent, the Class III TCLs form the basis for establishing multiple populations and eventually linking up areas if these places are incorporated into longer-term zoning plans by governments. Many of these landscapes are of great national and local importance and form the staging ground for the following decades, investments to save the tiger.

6.5.3 Recognizing reality

If the good news is that investments to save tigers and tigerness are still possible, the bad news is that the choices for investment, and the areas with tigers, are becoming fewer with each passing year. Beyond the Tropical Moist Forests and the Tropical Dry Forests, it's hard to find redundancy—that is multiple, independent areas that represent tigers in that biome type. "Redundancy" as a conservation planning principle is equivalent to the folk wisdom of "not putting all your eggs in one basket." Having multiple instances of tigers in different biomes would help insure against the unexpected loss of an area. Unfortunately regional representation isn't possible except in scattered instances. There are too many biomes where there is only one place to invest and in some cases, even that one place is less than optimal.

Another important consideration is that though we outline here an objective measuring stick for tiger conservation; in fact we lack the data to fully implement it. Ideally our measures of tiger population potential would be based on systematic assessments of tiger populations, not habitat, but that data is lacking for most of the TCLs outlined. We also lack almost entirely a sense of where the prey are and in what numbers, though anecdotal evidence suggests that wild prey animals (e.g. boars, wild cattle, wild deer) are declining across Asia as areas become more fragmented and accessible. Even our habitat classification, the best yet produced for tiger conservation, is lacking in many respect and the subject of much comment through our peer-review process (Chapter 4). For 22 of our TCLs we lack even the basic information on the level of threat and the conservation measures in place. Tigers need prey, habitat and freedom from persecution to thrive—our information base on all these points is imperfect and therefore our priorities, as described, need further verification with experts on the ground.

Finally we accept good science is necessary but not sufficient to conservation. Science tells us what tigers need and where it is needed, as outlined in this chapter; however, tiger conservation will require more.

Tiger conservation over the next decade will require building Tiger Conservation Landscapes into the development agenda of range states. Thus, we suggest several important areas for funding to define a holistic strategy, which includes a socialization campaign to take these results to decision-makers across Asia, recruiting spokespeople with the charisma and time to take the message of tiger conservation to the world, and working to integrate these results into regional land use and economic development plans, so that as Asia's economic tigers continue to rise, wild tigers are not left behind.

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Chapter 7 Putting Tiger Conservation Landscapes in Context: Protected Areas, Other Designated Areas, And Selected Megafauna

7.1 Protected Areas

Protected areas form the nucleus of protection for many tiger conservation landscapes (TCLs). Protected areas often conserve vital breeding areas, protect key habitat and prey species, and can serve as both a refuge, or a stepping stone for dispersal. Using the 2005 World Database of Protected Areas (WDPA Consortium 2005), and modified with additional information on protected areas from Thailand, Myanmar, and Riau Province, Sumatra, we assessed the degree to which the TCLs overlap with protected areas. IUCN recognizes six categories of protection, ranging from strict protection for biodiversity conservation (Category I) to areas managed mainly for the sustainable use of natural ecosystems (Category VI). We analyzed the percentage of TCLs found in all categories of protection, as well as a subset, selecting only those categories that place an emphasis on biodiversity conservation (Categories I-IV)(See Table 7.1; Figure 7.1).

	No. of Tiger Conservation Landscapes	Total TCL Area (km^2)	Median Size of TCL (km^2)	Number of protected areas (Number of TCLs containing a protected area)		Percentage of total TCL area in protected areas	
				IUCN Categories I-IV	All IUCN Categories	IUCN Categories I-IV	All IUCN Categories
TCL Priority							
Global	20	924,791	9,056	109 (19 of 20 TCLs)	216 (20 of 20 TCLs)	10.5%	19.7%
Regional	13	89,963	3,970	22 (13 of 13 TCLs)	46 (13 of 13 TCLs)	13.6%	30.0%
Long-term	21	66,960	1,486	24 (12 of 21 TCLs)	35 (17 of 21 TCLs)	25.7%	31.3%
Insufficient data	22	103,197	1,691	34 (14 of 22 TCLs)	45 (18 of 22 TCLs)	20.8%	42.4%
Bioregion							
Indian Subcontinent	40	227,569	2,154	95 (33 of 40 TCLs)	97 (35 of 40 TCLs)	15.4%	15.8%
Indochina	20	540,758	5,288	71 (16 of 20 TCLs)	178 (20 of 20 TCLs)	11.0%	29.2%
Southeast Asia	15	145,285	3,884	11 (8 of 15 TCLs)	32 (13 of 15 TCLs)	19.8%	36.5%
Russian Far East	2	271,298	135,649	27 (1 of 2 TCLs)	35 (1 of 2 TCLs)	9.6%	9.9%

Table 7.1 Overlap of TCLs with protected areas.

There are a total of 342 nature reserves representing 23.1% of the land area found within all TCLs (Table 7.1). On average, the Earth has about 13% of its land area under protection. Therefore, TCLs contain almost twice the global average of protection, demonstrating that formal protection is closely linked with tiger conservation areas. Taking a more strict definition of biodiversity protection—only analyzing those protected areas in IUCN Categories I through IV—we found that TCLs still had 12.5% of their land under protection.

When analyzed by priority level, the protection ranged from 20% in Global Priorities to 42% in those with Insufficient data (Table 7.1). Yet, while the Global Priority TCLs had the lowest percent of land protected, they also had the most total area under protection (182,324 km^2) which is between 4 to 9 times more than the other priority categories. In addition, the median size of Global Priority TCLs was at least twice as large as the Regional Priorities and significantly larger than Long-Term Priorities (Table 7.1). All Global and Regional Priority TCLs contained at least one protected area, reflecting both the value of protected areas in effective tiger conservation strategies. In all, only eight of the 76 TCLs did not overlap with a protected area.

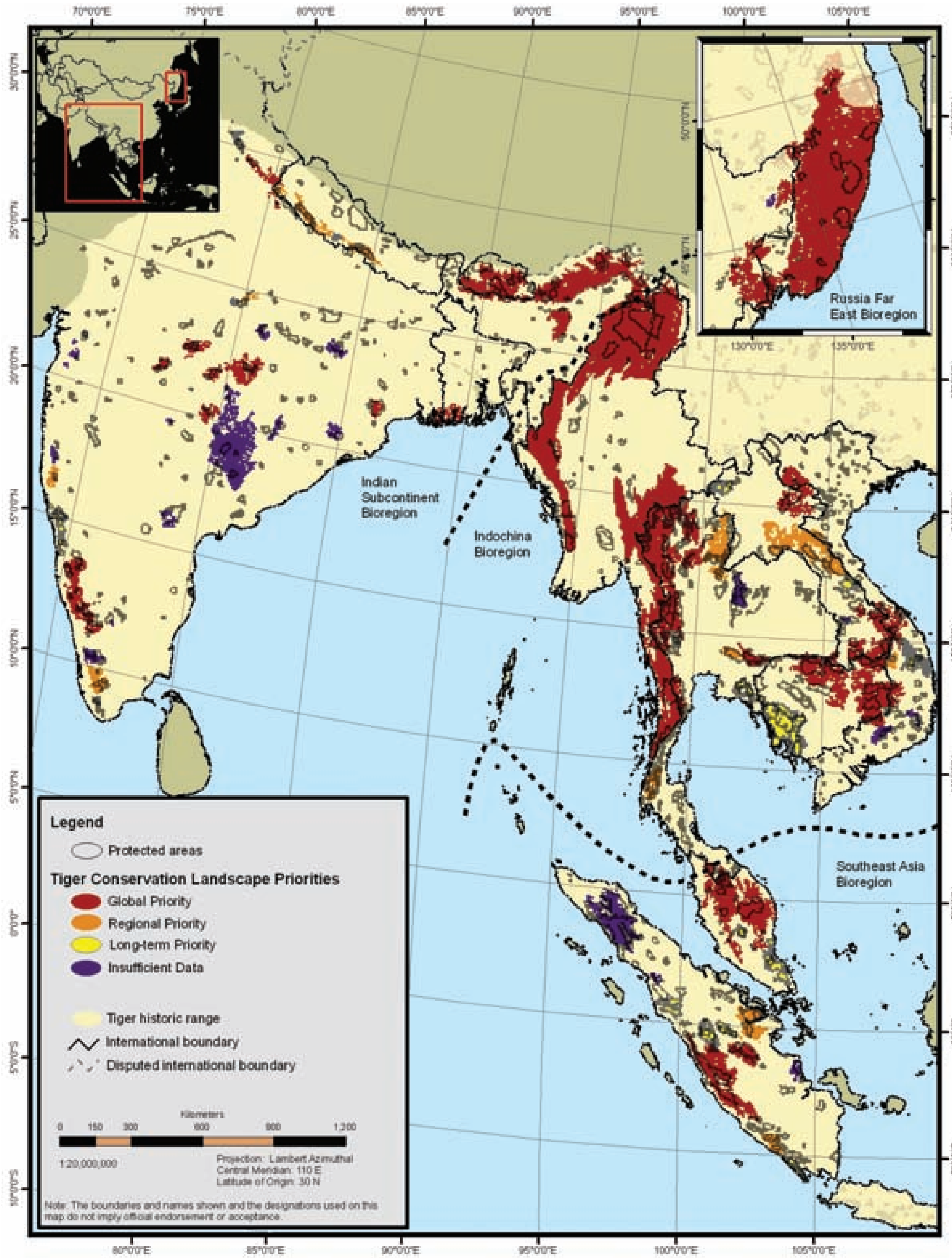

Fig. 7.1 Overlap of TCLs with WDPA (2005) protected areas.

TCLs of the Southeast Asia bioregion showed the highest percentage of protection, followed closely by Indochina. The Indochina bioregion has the largest median value of TCL size (excepting the Russia Far East which only has 2 TCLs). The Indochina bioregion also has more protected areas and total area within TCLs than the Indian Subcontinent and Southeast Asia bioregions. The Indian Subcontinent bioregion has a moderate amount of protection and protected areas inside TCLs. Due to the significant human influence across this bioregion, increased protection within TCLs will likely secure much-needed habitat.

7.2 Overlap of TCLs with areas identified by intergovernmental organizations

7.2.1 World Heritage Sites

In 1972, the United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted the international treaty—Convention concerning the Protection of the World's Cultural and Natural Heritage. Through this treaty, one of UNESCO's missions is to encourage the identification, protection, and preservation of cultural and natural heritage sites around the world considered to be of outstanding value to humanity. Cultural heritage sites refer to monuments, groups of buildings and properties with historical, aesthetic, archaeological, scientific, ethnological, or anthropological value. Natural heritage sites refer to outstanding physical, biological, and geological formations; habitats of threatened species of animals and plants; and areas with scientific, conservation or aesthetic value (UNESCO-WHS 2003).

There are 10 natural and 32 cultural World Heritage Sites (WHS) that are found within the current distribution of tigers—including areas both inside and outside TCLs. While no cultural WHS areas overlap with TCLs, eight natural WHS are found in 11 TCLs, placing additional conservation priority in these areas (Table 7.2, Fig. 7.2). Many of the natural WHS are important areas for tigers, underscoring the importance of these regions for the conservation of tigers. These include India's Kaziranga and Manas National Parks, Nepal's Chitwan National Park, Sumatra's Leuser, Bukit Barisan, and Kerinci National Parks, Thailand's Thungyai-Huai Kha Khaeng Wildlife Sanctuaries, and Russia's central Sikhote-Alin.

7.2.2 UNESCO Man and Biosphere Reserves (MAB)

UNESCO's Program on Man and the Biosphere (MAB) are internationally recognized areas that are intended to fulfill three basic functions: the conservation of ecosystems and species, fostering economic and human development which is socio-culturally and ecologically sustainable, and providing support for research, monitoring, education, and information exchange related to conservation and development (UNESCO-MAB 2005). There are 12 UNESCO MAB sites that overlap the current range of tigers. Seven of these sites overlap with six TCLs (Table 7.2, Figure 7.2). As with the WHS, several of the MAB reserves are important reservoirs for tigers, including Russia's Sikhote-Alin, India's Nilgiri ecosystem and Indonesia's Leuser National Park.

Name	Country	Type	TCL No.	TCL Class	TCL Priority
Central Sikhote-Alin	Russian Federation	World Heritage Convention - Natural	2	I	Global
Tropical Rainforest Heritage of Sumatra	Indonesia	World Heritage Convention - Natural	5, 4, 3, 14	I, II, III, IV	Global, Regional, Long-term, Insufficient Data
Thungyai - Huai Kha Khaeng Wildlife Sanctuaries	Thailand	World Heritage Convention - Natural	19	I	Global
Phong Nha-Ke Bang National Park	Viet Nam	World Heritage Convention - Natural	33	III	Long-term
Manas Wildlife Sanctuary	India	World Heritage Convention - Natural World Heritage in Danger List	37	I	Global
Kaziranga National Park	India	World Heritage Convention - Natural	38	I	Global
The Sundarbans	Bangladesh	World Heritage Convention - Natural	39	III	Global
Royal Chitwan National Park	Nepal	World Heritage Convention - Natural	40	II	Regional
San Jiang National Nature Reserve	China	Wetlands of International Importance (Ramsar)	2	I	Global
Beeshazar and Associated Lakes	Nepal	Wetlands of International Importance (Ramsar)	40	II	Regional
Vembanad-Kol Wetland	India	Wetlands of International Importance (Ramsar)	64	II	Regional
Sundarbans	Bangladesh	Wetlands of International Importance (Ramsar)	39	III	Global
Middle Stretches of Mekong River North of Stoeng Treng	Cambodia	Wetlands of International Importance (Ramsar)	26	II	Global
Berbak	Indonesia	Wetlands of International Importance (Ramsar)	10	IV	Insufficient Data
Sikhote-Alin Zapovednik	Russian Federation	UNESCO-MAB Biosphere Reserve	2	I	Global
Nilgiri	India	UNESCO-MAB Biosphere Reserve	66	I	Global
Hauy Tak Teak Reserve	Thailand	UNESCO-MAB Biosphere Reserve	19	I	Global
Mae Sa-Kong Ma Reserve	Thailand	UNESCO-MAB Biosphere Reserve	19	I	Global
Sakaerat Environmental Research Station	Thailand	UNESCO-MAB Biosphere Reserve	24	II	Global
Cat Tien	Viet Nam	UNESCO-MAB Biosphere Reserve	28	IV	Insufficient Data
Gunung Leuser National Park	Indonesia	UNESCO-MAB Biosphere Reserve	14	IV	Insufficient Data

Table 7.2 World Heritage Sites, Wetlands of International Importance (Ramsar Sites), and UNESCO man and Biosphere Reserves that overlap TCLs.

7.2.3 Ramsar Wetlands of International Importance

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (Ramsar 2005). Sites designated for inclusion become listed in the Ramsar List of Wetlands of International Importance. There are 35 Ramsar sites that overlap the current range of tigers. Six Ramsar sites overlap six TCLs (Table 7.2, Fig. 7.2). These areas may provide potential protected water resources and a prey base for tigers during parts of the year.

7.2.4 Elephants, Rhinoceros, and Orang-utans

The tiger's range overlaps with that of many species. A noteworthy subset of these species is also classified as threatened by IUCN's Red List Species program. This program, created in the 1960s and overhauled in 1994, intends to identify and document those species most in need of conservation attention if global extinction rates are to be reduced. There are three primary categories of threat, Vulnerable, Endangered, and Critically Endangered. While conservation of tiger habitat may serve as an umbrella for a number of these threatened species, there are several threatened large mammal species, characteristic to this region, much like tigers, which warrant special attention. These include the three rhinoceros species, Sumatran rhinoceros (*Dicerorhinus sumatrensis*), Javan rhinoceros (*Rhinoceros sondaicus*), Indian rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), and Orang-utan (*Pongo abelii*). With the exception of the Asian elephant (Endangered) all of these species are identified as Critically Endangered—the highest level of threat—by IUCN, and have undergone severe contractions in their historic range.

For these reasons, we highlight where the TCLs overlap extant populations of these species, so that investing in conservation of tigers will likely result in the conservation of one of these species too (Table 7.3 and Figure 7.3) (Sources: rhinoceros: Foose and van Strien 1997; elephant: Leimgruber et al. 2003; orang-utan: Wich et al. 2003, van Schaik et al. 2001).

— *Colby Loucks*

Species	Country	TCL No.	TCL Class	TCL Priority
Elephant	India	58	I	Global
Elephant	India	66	I	Global
Elephant	India	57	IV	Insufficient data
Elephant	India	59	IV	Insufficient data
Elephant	India	65	IV	Insufficient data
Elephant	India	67	IV	Insufficient Data
Elephant	India	45	III	Long-term
Elephant	India	46	III	Long-term
Elephant	India	63	III	Long-term
Elephant	India	69	III	Long-term
Elephant	India	64	II	Regional
Elephant	India, Nepal	44	I	Global
Elephant	India, Nepal	40	II	Regional
Elephant	Nepal	43	II	Regional
Elephant	Myanmar, India, Bhutan	37	I	Global
Elephant	Myanmar, Thailand	19	I	Global
Elephant	Thailand	24	II	Global
Elephant	Thailand	22	IV	Insufficient data
Elephant	Thailand	18	II	Regional
Elephant	Thailand	23	II	Regional
Elephant	Thailand, Cambodia	26	II	Global
Elephant	Cambodia	25	III	Long-term
Elephant	Laos	33	III	Long-term
Elephant	Laos	21	II	Regional
Elephant	Laos, Vietnam	35	I	Global
Elephant	Laos, Vietnam	34	II	Regional
Elephant	Vietnam	31	II	Regional
Elephant	Vietnam, Cambodia, Laos	27	I	Global
Elephant	Malaysia	15	III	Long-term
Elephant	Malaysia, Thailand	16	I	Global
Elephant	Indonesia	5	I	Global
Elephant	Indonesia	7	I	Global
Elephant	Indonesia	10	IV	Insufficient data
Elephant	Indonesia	14	IV	Insufficient data
Elephant	Indonesia	3	III	Long-term
Elephant	Indonesia	4	II	Regional
Elephant	Indonesia	9	II	Regional
Indian Rhinoceros	India	37	I	Global
Indian Rhinoceros	India	38	I	Global
Indian Rhinoceros	Nepal	40	II	Regional
Indian Rhinoceros	Nepal	42	II	Regional
Sumatran Rhinoceros	Thailand	22	IV	Insufficient data
Sumatran Rhinoceros	Thailand, Myanmar	19	I	Global
Sumatran Rhinoceros	Thailand, Malaysia	16	I	Global
Sumatran Rhinoceros	Malaysia	15	III	Long-term
Sumatran Rhinoceros	Malaysia	17	III	Long-term
Sumatran Rhinoceros	Indonesia	14	IV	Insufficient data
Sumatran Rhinoceros	Indonesia	11	III	Long-term
Sumatran Rhinoceros	Indonesia	12	III	Long-term
Sumatran Rhinoceros	Indonesia	3	III	Long-term
Sumatran Rhinoceros	Indonesia	4	II	Regional
Sumatran Rhinoceros	Indonesia	5	I	Global
Sumatran Rhinoceros	Indonesia	10	IV	Insufficient data
Javan Rhinoceros	Vietnam	28	IV	Insufficient data
Orang-utan	Indonesia	13	IV	Insufficient data
Orang-utan	Indonesia	14	IV	Insufficient data

Table 7.3 Overlap of select endangered megafauna with TCLs.

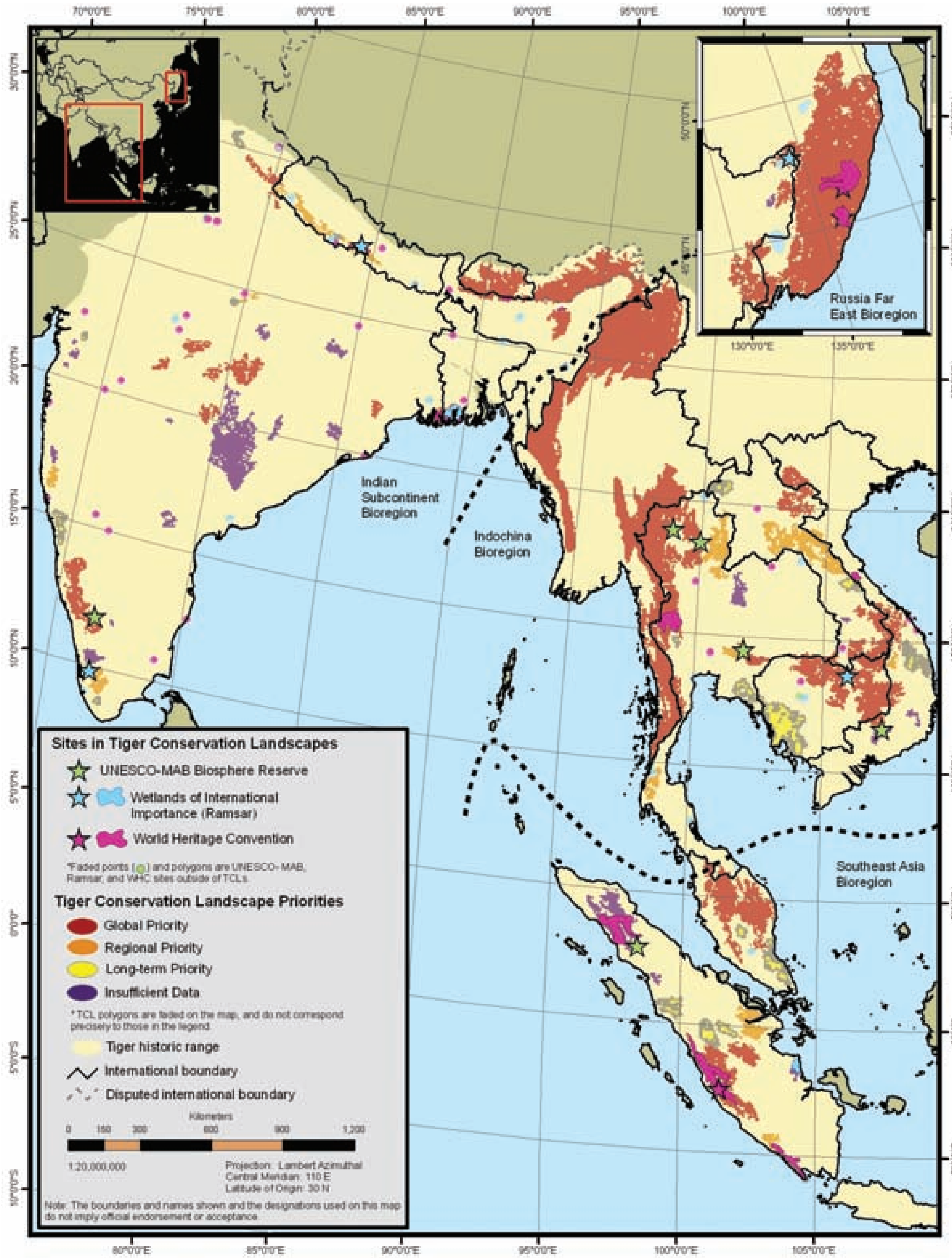

Figure 7.2 Overlap of TCLs with UNESCO MAB reserves, Ramsar sites, and World Heritage Sites.

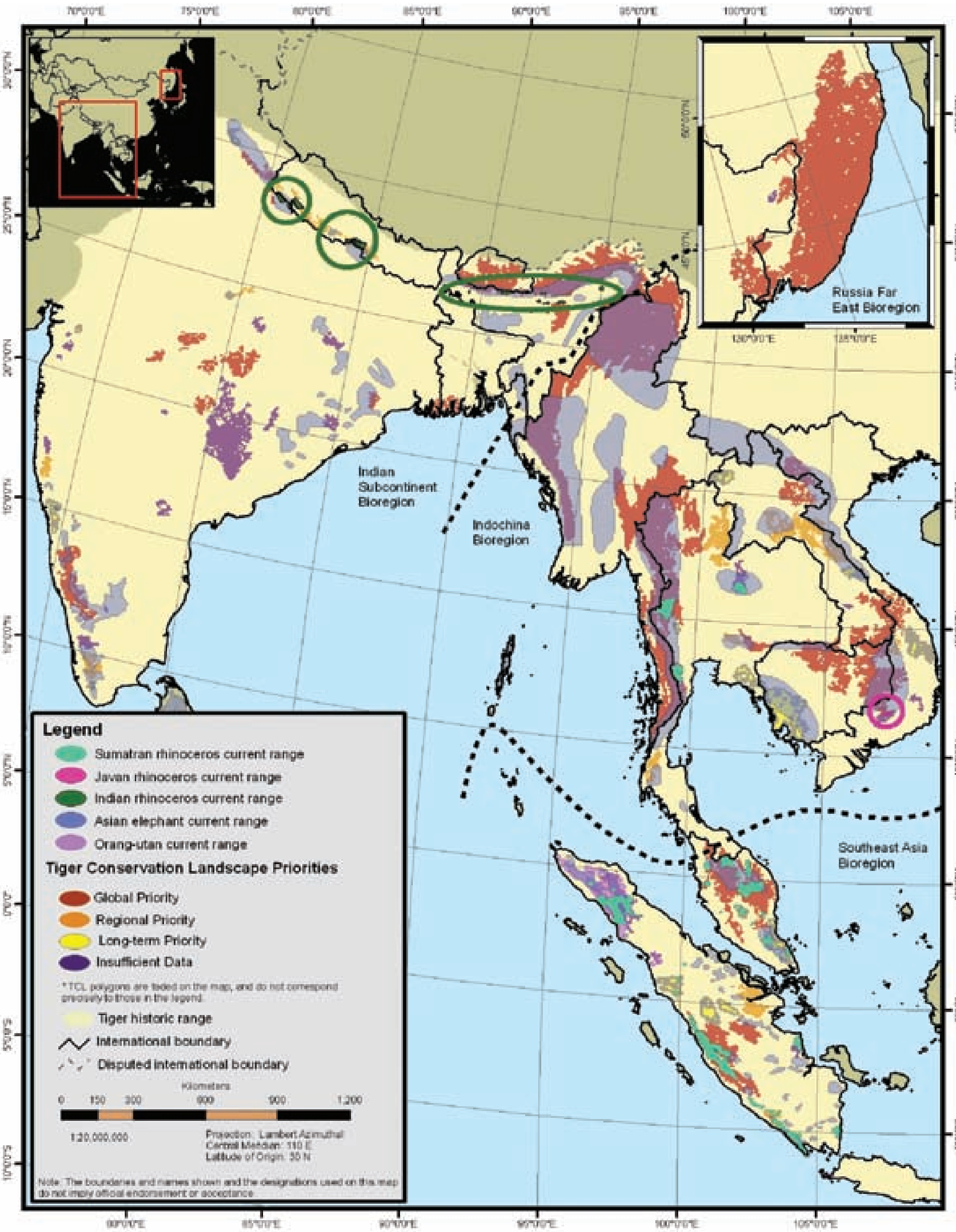

Figure 7.3 Overlap of TCLs with select endangered megafauna.

Chapter 8 NGO Investment in Tiger Conservation Units, 1998–2003

8.1 Introduction and Data Constraints

One of the main objectives of the 1997 TCU 1.0 Framework Document was to create a framework that would assist in effectively guiding resources and efforts, in the shape of funding and research to help conserve tigers. Funds for conservation are limited, this we know, but since TCU 1.0, the question arises as to how much funding has been spent on conserving tigers, and to where has it been allocated: have donors invested in top priority TCUs identified in TCU 1.0? Data for funding tiger conservation presented here is from the IUCN/SSC Cat Conservation Projects Database. This database has a secure and private online data entry and reporting interface and is scheduled to become publicly accessible in 2006. Currently, funding data are supplied by all of the major implementing and funding NGOs for tiger conservation, as well as some of the much smaller organizations, and data have been crosschecked to prevent duplicated entries in the database.

For the years between 1998 and 2000, the existing funding data for investment in tiger conservation are both complete and of high quality. Data entry for 2001 to 2003 is almost complete however information from a few of the smaller agencies is missing. A breakdown of WWF India's Tiger Conservation Program by geographical area has not yet been obtained for 2001 to 2003 and for the purposes of this analysis we had to assume that WWF continued to focus on the same areas and in approximately the same proportions as they did during 1998 to 2000. WWF figures of total funding for the program between 2001 and 2003 have been distributed accordingly among the TCUs presented in the table below. These approximate entries will be refined during 2005.

Government funds, which are used for operating protected areas for example, are not included, and non-tiger-directed funds are included only partially and only where they clearly have potential to benefit tigers. Other factors affecting the accuracy of financial records include: differing financial years between institutions; variations in exchange rates; bank transfer fees; and administrative costs, all of which have been accounted for.

There are several ways to run geographically based database reports: 1. All funds allocated to the single most important TCU (or country) in the project; 2. Funds appropriately split between TCUs (or countries) with Key Focus or Substantial listing for each project; 3. Funds appropriately split between all TCUs (or countries) involved in the project no matter how marginally. All reports used here have been run with country Key Focus and/or TCU All settings. The TCUs referred to in this chapter are the TCUs which were delineated and prioritized in TCU 1.0.

8.2 Funding of Tiger Conservation Across TCUs (TCU 1.0)

Table 1 represents the top 52 TCUs with the highest recorded levels of funding. This is the maximum number of TCUs that can be reported on with the database's current reporting options; it leaves only a few small TCUs, all in India and all with recorded investment of less than $10,000, grouped together and categorized by "other".

TCU	Amount	TCU	Amount
107 Bach Ma-Nui Thanh	$10,000	44	$179,303
90 Nui Hoang Lien	$13,776	27 Bagdara-Hazaribagh	$213,738
7	$13,858	99 Nam Theun Nakai-Vu Quang	$220,303
8	$13,858	101 Phu Khieo-Nam Nao	$255,883
62 Arakan Yomas	$14,500	3 Dudwa-Kailali	$261,790
152 Berbak-Sembilang	$19,980	24 Panna-Son Gharial	$269,650
47 Sitapani-Udanti	$28,265	60 Northern Triangle	$334,978
122 Kulen Promtep-Thap Lan	$29,453	18 Sunderbans	$341,814
145 Gunung Leuser-Lingga Isaq	$29,760	61 Chin Hills	$373,924
94	$46,232	1 Rajaji-Corbett	$416,540
46 Indravati-Navegaon	$52,101	73 Huay Kha Khaeng-Thung Yai Naresuan	$481,967
48	$56,364	2 Sukla Phanta-Kishanpur	$567,339
9	$56,585	113 Virachay-Xe Piane-Yok Don	$607,591
110	$60,303	161 SW Primorye and North Korea	$632,912
162 Heilongjiang area	$63,581	159 Way Kambas	$688,089
163 Southern China	$64,858	158 Bukit Barisan Selatan-Bukit Hitam	$696,187
93 Song Da Forest	$69,348	129 Taman Negara	$699,007
63Shan Plateau	$74,600	20 Ranthambore	$739,540
39 Simlipal-Kotgarh	$82,916	6 Chitwan-Parsa-Valmiki	$805,076
5	$95,128	125 Phnom Bokor-Aural	$904,540
12	$111,102	121 Khao Yai	$917,770
19	$115,355	4 Bardia-Banke	$1,013,423
Other	$118,558	55 Dandeli-Bandipur	$1,156,849
31 Kanha-Pench	$124,732	10 Manas-Namdapha	$1,479,037
154 Dangku	$132,200	148 Kerinci Seblat-Seberida	$1,666,372
28 Melghat	$139,401	160 Russian Far East	$5,656,444
16 Kaziranga-Meghalaya	$175,864		

Table 8.1 Expenditure per TCU 1.0, 1998-1003 inclusive.

The total recorded expenditure in TCUs is $23,392,744. This figure covers only "on the ground" projects and does not include funds spent on non-geographically focused measures such as national educational program, conferences, publications, and wildlife trade investigations. The total recorded spending in all categories for the same period is $31,0064,009. This means the ontheground funds represent 75% of the total spending. Eighty-six percent of this on the ground funding has gone to just twenty TCUs, and 64% has gone to the top ten: the Russian Far East, Kerinci Seblat, Manas-Namdapha, Dandeli-Bandipur, Bardia-Banke, Khao Yai, Chitwan-Parsa-Valmiki, Ranthambore and Taman Negara. These are all Level 1 TCUs except for Ranthambore, and include some of the most important tiger areas in five countries (India, Russia, Indonesia, Malaysia, and Nepal). Ranthambore's presence in the top ten despite its level III rank is indicative of its "ambassador" value as a place for visitors to see tigers, as well as of the efforts of dedicated individuals associated with the park over the years.

The difference between the amount of funding allocated to the top-ranked TCU160 in the Russian Far East and the rest of the TCUs—TCU160 has received 24% of the total TCU budget—is due, in part, to the fact that it represents virtually all the remaining habitat in Russia and quite possibly the world's single largest remaining unfragmented population of tigers. Donors consider Russia a good investment for these reasons, as well as the low human density, strong collaboration among NGOs, and a history of conservation based on good science.

TCU investments grouped by bioregion show that the Indian subcontinent has received the majority of funds (36.5%), followed by the northern temperate. The spread of funding here is very similar to that presented during the Society of Conservation Biology Conference in 2002, showing proportional rises in investment most notably in Indonesia (mostly but not entirely in Kerinci Seblat-Seberida) and in Malaysia (almost entirely in Taman Negara).

Preliminary investigations of the spread of funding with reference to project activities highlights several interesting differences between Russia and India. For example, proportionally much more is spent on ecological studies and monitoring in Russia than in India. Both countries have a strong emphasis on protection measures but in India these are almost all focused at the reserve level while in Russia efforts are more wide-ranging, operating between protected areas and with more coordination across the country in terms of both antipoaching and wildlife trade investigations. More is spent in India on factors targeted at living alongside tigers than in Russia and, less predictably, considerably more funds go towards education and awareness work in Russia than in India.

Currently, it is not possible to produce a report indicating which agencies have invested in the individual TCUs, but the improvements to the database in 2005 will enable such reports. A large-scale analysis of funding sources from 1998 to 2003 reveals that the two most significant donors are WWF and the STF with 28% and 25% respectively, followed by WCS and the USFWS with 10% and 8%, and then 21st Century Tiger and the David Shepherd Wildlife Foundation at 3%.

8.3 Next steps

In order to assess the effectiveness of our investments in TCUs, and adjust our planning accordingly, we must monitor the status of the target areas. Inclusion of fields in the database for key indicators of success in each TCU will possibly help produce charts showing, for example, changes in investment focus over time plotted against trends in tiger or prey density, habitat integrity, human disturbance, incidences of poaching, human attitudes, etc. Advice from the tiger conservation community on what fields to create for this purpose, and how to obtain the necessary data is needed.

It is already clear which TCUs have received the majority of the funds to date, and the current state of knowledge of at least two of them (the Russian Far East 160 and Dandeli-Bandipur 55) should be sufficient for further analysis. ZSL plans to produce at least two papers, one of which will focus on the effectiveness of investments, during 2006.

— *Sarah Christie*

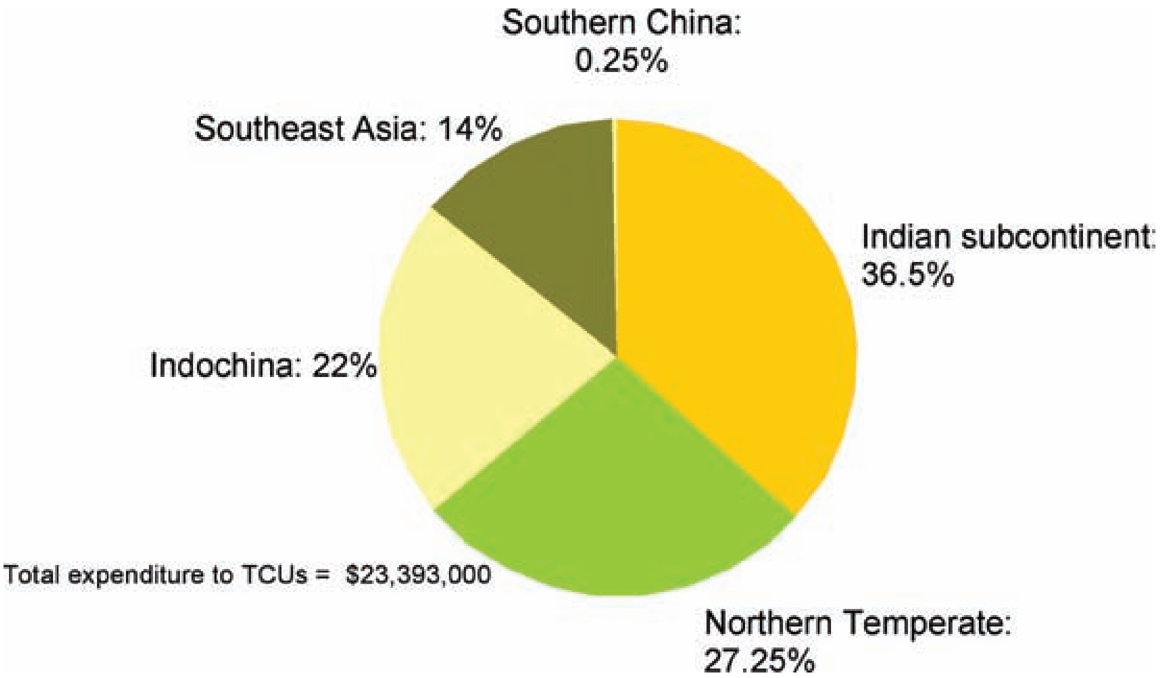

Figure 8.1 TCU investment by bioregion 1998-2003

Chapter 9 Recommendations for Improving the Process

In the preceding sections we have developed a delineation process that defines current tiger habitat and a taxonomy that informs us of the current status of tigers across their range. Using this taxonomy, we have made recommendations for the priorities for tiger conservation over the next decade, with our recommendations ensuring that tigers will persist, we hope flourish, in representative habitats and areas across their range.

The methods that we have used to delineate TCLs, that form the basis of the taxonomy, and which help us set priorities for tiger conservation, have drawn on a number of sources of information and data. We have endeavored, wherever possible, to develop methodologies that are transparent, systematic, and easily repeatable so that we can continue to refine, and modify this analysis as new data become available. We have, we hope, fulfilled our commitment to make this a living document. Meeting that commitment puts greater value on improving the datasets on which we based our analyses as this will allow us to refine and revise recommendations on something less than a decadal scale.

Our desire to set range-wide priorities required datasets that, for the most part, had a range-wide scope. No dataset is perfect, and in many cases, we were unable to include data because it was too fragmentary across the range of the species. Nonetheless, the process has identified some clear gaps in our data, and in this section of the report we discuss priorities for improving the data, and the process, of our analyses.

9.1 Recommendations for the Land Cover Data

Access to satellite imagery and geospatial analysis technologies (e.g. GIS, GPS) has expanded dramatically since the last TCL analysis, making possible the acquisition of detailed information about habitats over large areas and at frequent time intervals. Despite the recent malfunctioning of Landsat 7 (USGS 2003), which probably will end the 30-year succession of Landsat satellites and images, new high- and mid-resolution data are likely to increase in availability. For example the ASTER (15 m) and MODIS (250 to 500 m) sensors onboard Terra already provide interesting alternatives to Landsat (Abrams 2000; Friedl et al. 2002). However, free Landsat data sets for almost all areas on the globe are already available for the 1990s and 2000s (Tucker et al. 2004). The limiting factor in the future most likely will be the cost and time necessary to analyze hundreds of satellite images rather than the resources required to purchase satellite data.

In this revision of TCLs, we would have liked to have collated all available Landsat satellite imagery for the tiger range, map habitats and assess habitat changes over the past two decades. However, time and resource constraints did not allow for such an analysis. Instead we compiled all existing data. The results from our land cover compilation and mapping were sobering. Despite the availability of Landsat images for most of the tiger range, few areas had detailed land cover maps available. In addition, classification schemes among these areas were very different, making integration of the data into a single tiger land cover map difficult and problematic.

Habitat loss, fragmentation and degradation are major threats to tiger populations. Habitat extent and the rate at which remaining habitat are disappearing are among the conservation measurements that could be determined fairly consistently and easily. In fact, regular acquisition of satellite data may even provide some sort of early warning system to identify areas where threats to tiger habitats and the associated populations are increasing rapidly. Similar early warning systems for detection of vegetation changes have already been proposed for MODIS data and are in an experimental phase at NASA.

One of the most important 10-year goals for tiger conservation should be the creation of a consistent and accurate map of remaining tiger habitats that also provides estimates on habitat conversion rates for different areas. This ambitious goal is probably best achieved in several steps:

1) Compile comprehensive satellite image archive for all tiger TCLs. (It will take roughly 700 Landsat images to map the historic tiger range; only about 100 to map current TCLs (see Chapter 3, Figure 3.3);

2) Make digital and hardcopy images widely available for tiger surveys, monitoring, and conservation projects funded by Save The Tiger Fund and USFWS;

3) Create partnerships with NASA, JPL, USGS to assure satellite image acquisition over these areas in the future—international NGOs should probably continue to push for regular wall-to-wall global coverage as was done for the creation of Geocover (Tucker et al. 2004);

4) Create basic land cover/habitat maps based on satellite images (these should use a consistent methodology and land cover classification system);

5) Combine satellite images from different dates to determine rates of habitat loss in TCLs;

6) Make all spatial data widely available through an Internet portal (by putting maps into public domain, conservation organizations can encourage greater data sharing among groups).

These data would not only benefit tiger conservation. Many of the TCLs represent remaining intact landscapes in Asia that also support a wide range of other important species.

9.2 Recommendations for Tiger Location, Density, and Breeding Data

In 1995, we recognized the importance of tigers to our analysis, but our knowledge of tiger status—even at the level of presence and absence—was sufficiently weak that these data were not weighted heavily in setting priorities in the original Framework document. In the current analysis, and in particular in developing the TCL taxonomy, we have placed increased importance on our current knowledge of the distribution of tigers, and on the distribution of breeding populations of tigers across tiger range. In large measure, we were able to highlight the importance of tiger location and breeding data because of the investment in surveys, and the development of better monitoring techniques (Carbone et al.; Karanth et al. 2004a, 2004b; Miquelle et al. 1999).

Our methods, however, were not without problems. In order to have sufficient data across the range of tigers, we have had to use a very coarse filter in our analysis—all tiger point location data was included in our analyses, and there was a wide variation in quality of these data. Some TCLs benefited from detailed camera trapping data that indicate not only occurrence, but in some cases both absolute or relative density (Karanth et al. 2004a; 2004b; Carbone et al. 2001). Point locations in some TCLs were derived only from interview surveys (e.g. much of Cambodia: Nowell et al 1999) despite that follow-up surveys indicate that these survey data were flawed, or there has been a recent, and severe, contraction of range of tigers in Cambodia (briefly summarized in Weiler and Pantel 2004). The implications of using such a coarse filter are significant (Karanth et al. 2003), and we aim to improve the data available for the final report through a process of expert review and collection of additional data.

It is distressing nonetheless, that despite significant expenditures for research and conservation of the tiger, there is no central source for current, range-wide tiger distribution information. Collecting the data for this exercise, as it is for most large-scale, range-wide exercises, was sometimes like pulling teeth. Through the process of developing this analysis, we have collated the vast majority of published information on recent distribution of tigers; however, we are also aware that a huge amount of information remains unpublished, and that despite our best efforts, a significant proportion of data were unavailable for our analyses. Because there is no current, systematic way to capture point-location data on tiger presence, and absence, it remains impossible to easily answer simple questions: where are tigers now and where are we looking for them? Capturing published and, more importantly, unpublished information in a standardized format is essential. Capturing unsuccessful tiger surveys (if there is such a thing) is equally important to learn where tigers are absent. Finally, recognizing the efforts of tiger researchers is important to foster a spirit of cooperation among tiger biologists and promote the exchange, rather than the sequestering of important data.

One of the most important 10-year goals for improving our ability to set priorities for tiger conservation should be the creation of a database that will provide for an annual, repeatable, scientific assessment of the known distribution of tigers. A prototype of such a database was developed by the Wildlife Conservation Society to manage its own tiger data and was used in our current analyses. Such a database will have the following key attributes:

- The database will collect point location data on tiger survey, survey effort, and results of the survey (presence/absence; density etc.).
- Data will be accepted from all tiger conservationists working in different countries, different institutions and different cultures, gathered in range nations in a standardized manner and disseminated directly to the decision-makers who ultimately will determine the fate of the tiger.
- Database entries will clearly tag the method of survey
- All contributions would be voluntary. In exchange for a minimal data contribution, the contributor and their institution would be publicly acknowledged and the contributor and their institution would receive a letter acknowledging their contribution.
- All contributors will be eligible to apply for a complete distribution of the dataset.

9.3 Establishing Gold Standard Baselines

Over the last decade conservation efforts have been catalyzed across the tiger range by support of the STF and other donors. Yet few projects include monitoring of tigers, or their prey, as an explicitly stated part of their conservation strategy. While expenditures on monitoring may seem like a black hole, and some feel that we risk counting tigers into extinction, the need for some form of monitoring in each significant tiger conservation landscape is critical. The way in which these monitoring programs are designed critically affects the ability of the studies to provide useful data (see Karanth et al. 2003). In many places surveys that focus on tracking relative densities of tigers and their prey in representative habitats may be sufficient. However, in developing our priorities for tiger conservation we identified a lack of well-stratified, statistically robust, monitoring programs as a continuing problem in assessing the status of tigers, understanding trends in numbers (either relative or absolute) and in assessing the effectiveness of our conservation efforts over the long-term.

Perhaps the most ambitious program is that conducted under the Amur Tiger Monitoring Program, a program that has received strong, and consistent support of STF and other donors. Initiated in 1997, the program monitored trends in the population of tigers and their prey (Miquelle et al. 2003). Sixteen monitoring sites are distributed across the range of Amur tigers to ensure representation of parameters relevant to tiger abundance (protected status, north-south and east-west gradients). The program aims to provide a mechanism that will assess changes in the density of tigers, as well as other potential indicators of population status, within their current range over long. This program complements an even more ambitious project—a full range survey of tigers across the Russian Far East. This survey mobilizes hundreds of participants to count tiger tracks in the snow across the range of the species in Russia. The first survey, was organized in 1995–1996 largely out of concern over the status of the population after the poaching crises of the early 1990's. The results of this survey provided a robust set of baseline data that indicated that there were 330 to 371 adult tigers, and some 100 young in the Russian Far East. This survey was repeated in February 2005.

The surveys in the RFE provide exceptional clarity on the status and trends in tiger numbers in that region. While it is probably unrealistic to assume that we can develop such systems range-wide (the lack of snow across tiger range complicates the process), we nonetheless feel that establishing gold-standard baseline monitoring programs that are stratified across habitat, ecoregion, and political boundaries would greatly enhance both our knowledge about the status of tigers, and our ability to focus conservation efforts. Such a system would serve to help develop best practices for tiger conservation by enabling us to assess the effectiveness of our actions, and serve as an early-warning system for the tiger population trends range-wide.

9.4 Closing the Knowledge Gap

The first Framework document highlighted the extent of our ignorance about tiger status and distribution. As a result, many large, and critically important, areas have been surveyed and assessed for the status of tigers, and the threats they face. In Cambodia, Myanmar, Malaysia, Vietnam, Lao PDR, south China, Indonesia, and elsewhere in tiger range, new surveys have given us an insight into the true state of tiger populations across the range of the species. The results have not always been ones that have made those of us who care about tigers happy—across much of Cambodia and Myanmar, for instance, the surveys documented extensive local extirpation of tigers. But these surveys have helped identify the key, and often critical, areas for future conservation efforts, reducing the scope of our uncertainty, and increasing the leverage, and focus, of our efforts to secure core tiger populations, manage prey populations, and eventually revive tiger populations in the extensive, if depleted, habitat that still remains.

Yet, in this new analysis, many areas remain as a priority for survey—either explicitly, or implicitly. While many of these areas will no doubt prove a disappointment, some may harbor critical populations of tigers. For instance, the vast expanse of the Gunung Leusur Reserve in northern Sumatra is, no doubt, some of the best habitat available for Sumatran tigers. While the political situation in the region is daunting, a lack of systematic surveys of the area leaves the status, and importance, of this TCL uncertain. Nonetheless, conservationists remain hopeful that the vast expanse of Leuser will ensure the persistence of tigers in the reserve. Furthermore, the recent post-tsunami peace process in Aceh Province gives the first opportunity in a decade to organize a significant field survey in the region. Hence, we recommend strongly that surveys of currently unknown areas be conducted to ensure that we are investing our funds, and efforts, in those places that offer the best long-term hope for tigers.

9.5 Prey Data & Annual Sampling Efforts

For decades, tiger biologists have known that a healthy prey base is a necessary, if not sufficient, criterion for a health tiger population (Seidensticker 1987). From India (Karanth et al. 2004b) to the Russian Far East (Miquelle et al. 1996; 1999) to Indonesia (O'Brien et al. 2003), studies have shown the critical importance of tiger prey in sustaining healthy tiger populations. In recent years, studies have given us insights into the current status, and natural levels, of tiger prey in a number of habitats (e.g. Jathana et al. 2003; Miquelle et al. 1999, unpublished). In the Russian Far East and north-east China, in parts of India, and in one reserve in Indonesia, established baselines allow us to monitor efforts to protect and recover tiger prey: such data, collected in a systematic and long term fashion, are lacking from across the tiger's range.

With the exception of Russian studies that look across a range of land-use types, most surveys of prey that have been conducted have tended to focus on studies on prey densities in protected areas: while a critical, and important first step, the lack of well stratified data from outside areas of full protection makes it very difficult to extrapolate those few data we have in any meaningful way. Furthermore, data on prey availability outside of protected areas is critical to developing our understanding of connectivity and landscape-level processes.

While this report has jump-started the process of development of a synthetic database that captures information on tiger presence/absence, and densities, no such database or collation of data exists for studies of tiger prey: data on surveys for tiger prey is rarely captured in any systematic way. Reams of data on the distribution and relative capture rates of prey, collected in camera-trapping surveys for tigers and other individually-marked animals, remains unanalyzed, and often is poorly curated. Because recent efforts that link camera trapping to line-transect analyses suggest that algorithms can be developed to link relative capture rates to absolute abundance (e.g. O'Brien et al. 2003) the real value of these data has often been underestimated.

In our questionnaire survey, data on tiger prey was notably absent. In part this was because of a lack of specific questions on the issue, but even in those questions asked, response rates were poor. Subjective analysis of prey populations, while perhaps valuable for determining broad, long-term trends, is inadequate for managing tiger populations.

Given the critical importance of prey to both the maintenance and recovery of tiger populations, we strongly recommend that a systematic effort be made to both capture existing information on prey density and abundance, and to develop a large-scale, stratified survey to estimate and monitor prey levels across the range of the tiger.

— Joshua Ginsberg, John Seidensticker, Eric Dinerstein, Peter Leimgruber

Epilogue

The tenuous relationship between tigers and humans has pushed the wild tiger to the brink of extinction. Poised at the top of the ecosystems where it lives, the endangered tiger is an indicator of ecosystems in crisis. People continue to kill tigers and to overwhelm landscapes where tigers live. Tigers are under constant threat from poaching to satisfy the unremitting demand for tiger parts used in folk medicine and for ornamentation. To save wild tigers, we must devise strategies to eliminate the consumption of tigers. People continue to destroy, fragment, and degrade existing and potential tiger habitats. Overharvesting of the tiger's prey causes injury to the cycle of human-wildlife coexistence in most of the remaining forests of Asia where tigers still survive. To save wild tigers, we must create landscapes friendly to both tigers and humans. We have insufficient knowledge of what tigers need to survive in the changing landscapes of Asia and inadequate tools to meet these needs. To save wild tigers, we must catalyze efforts to increase knowledge, skills, and cooperation to support wild tiger conservation. Wild tigers suffer from a lack of recognition and visibility to mobilize multi-sector support. To save wild tigers, we must gain recognition, visibility, and support to make wild tigers valuable to people.

Incomplete knowledge of the state of tiger populations has made it difficult to set priorities and agendas for action. We will never have all the information we need, but the powerful images, evidence, and narrative in the 1997 Framework Document (TCU 1.0) established the first baselines on which to establish a common agenda and set of priorities for conservationists striving to save wild tigers across Asia. TCU 1.0 brought an unprecedented degree of information together for the first time and began to translate the many different languages used in tiger conservation into the common language and science of conservation biology. It instilled hope that with concerted effort the resilient tiger could be brought back from the brink of extinction by people working together with a common vision and understanding of the tiger's needs in human-dominated landscapes. Because it addressed tiger conservation at a range-wide scale never attempted before, it showed how enduring partnerships among governments, non-government organizations, businesses, and social and religious institutions are necessary to secure a future for wild tigers.

A principal lesson from TCU 1.0 was the need to move from a reactive to a proactive tiger conservation agenda. But TCU 1.0 is a static document. In the face of continually shifting natural and political landscapes in Asia, TCU 1.0 was being outflanked by new emerging threats and changing conditions on the ground and internationally. In 2003 the Save The Tiger Fund and its partners—The Wildlife Conservation Society, World Wildlife Fund-US, Smithsonian's National Zoological Park, U.S. Fish and Wildlife Service, UN Foundation, and Zoological Society of London— commissioned this project "Setting Priorities for Conservation and Recovery of Wild Tigers: 2005–2015" and worked with tiger conservationists across the tiger's range to catalyze efforts to increase knowledge, skills, and cooperation to support wild tiger conservation. This is a "living document" and will continue to be updated, which is essential to enable us to predict emerging changes and threats to wild tigers and rapidly communicate these to our partners so we can develop our strategic solutions together. Sustained conservation of wild tigers in ever-changing environments requires strategic and flexible allocations of resources to key tiger landscapes, anchored by new leadership capacity, sound sciences, best business practices, and public awareness.

Our vision is a world in which wild tigers thrive in natural habitats across their Asian range in harmony with people. People save what they value. To secure a place for wild tigers in our world, live tigers must be worth more to people than tiger parts, and landscapes with tigers must be worth more to people than landscapes where tigers are extinct. Wild tigers can be indicators of achieving large-scale conservation and improved human livelihoods. The tiger is a conservation-dependent species and isolated efforts are not enough to address today's threats to tigers. Saving the tiger requires continuous and concerted vigilance and effort. There is no universal formula for saving wild tigers, but by building on the foundations of earlier efforts, such as the national park, wilderness, and biodiversity conservation movements; by fostering a global commitment to tiger conservation; and by linking conservation and human welfare, we can harness flexible strategies to secure the tiger's long-term survival.

The challenge of saving the tiger is the heart of conservation. A world without tigers is a world without hope—like a clear night sky without stars. A world without tigers would be a terrible loss, symbolizing a morbid disregard for natural places and our natural heritage. Help us to save wild tigers. We see saving the tiger as a test: if we pass, we get to keep the planet.

— *John Seidensticker, Ph.D.*
Chairman, Save the Tiger Fund Council

A1–1 Cover Letter

May 9, 2004

Dear Tiger Researcher and Conservationist,

In 1995-1996, tiger conservationists, with support of Save The Tiger Fund and led by researchers at the World Wildlife Fund and the Wildlife Conservation Society, prepared a Framework Document for conservation of high priority areas and actions for tiger conservation (Dinerstein et al. 1997). This is a powerful document and is a new vision of how to think about saving tigers on their home ground. I love how the authors did not use the words “plan” or “strategy” in the title. In my mind, this document has been a vision with its powerful images and quantities, evidence, and narrative. This vision is grounded in sustainability, landscapes, bioregions, and in tiger ecology. It plays the key role in bridging the fundamental disconnection between development and formulation of a strategy and its implementation. In short—this document has had a central place in moving tiger conservation forward across the tiger’s entire range.

Ten years have passed since we initiated the first Framework Document for tiger conservation, and in that time much has changed. Funding for tiger conservation has increased significantly and much research and conservation has been supported by range states, by Save The Tiger Fund, and by the U.S. Fish & Wildlife Service Rhinoceros & Tiger Conservation Fund (USFWS). As a result, we know a lot more about the status of tigers across their range. In addition, technology has moved forward in leaps and bounds, bringing the potential to revise and refine our cover maps for Asian forests. New datasets on the impact or “footprint” of humans also allows us to consider what we know about tigers and forests in a new perspective. Clearly, a decade later, it is time to revise the Framework Document.

The Save The Tiger Fund, in collaboration with the USFWS, the U.N. Foundation, and the Critical Ecosystem Partnership Fund, have provided funding to the original NGO partners—WCS and WWF—and to the Smithsonian Institution (SI) to work on revising the Framework Document. Each of these institutions has also made significant contributions in funds and staff time to move forward this process. Without your help, however, we will not be able to meet our goal of using the best available information to set priorities for the next decade of tiger conservation. To meet this goal we need to bring together the information that everyone in the tiger community has worked so hard to collect. While the past decade has seen many studies undertaken of tigers, their prey, and the threats which face them, nowhere has even the most coarse-grained data been brought together to help us see the broader picture of the status, and future, of tigers in the wild.

We have attached two surveys to this e-mail, or this document, that we hope will help all of us bring together the most current information on tigers. The purpose of these two surveys, the Tiger Conservation Database Survey (TCDS) and the Tiger Conservation Unit (TCU) Questionnaire, is to document the current state of knowledge about tiger conservation in order to prepare the groundwork for a revision of the Framework Document. The results of the surveys will be compiled and shared widely to enhance our knowledge about tigers, identify gaps in our understanding, understand changes that have occurred since 1995, and inform new priority-setting and conservation investments.

You are receiving this material because you are acknowledged as an expert on tigers in all or some part of the tiger's historical range. Each piece of information provided by you will be tagged with your name and institutional affiliation and distributed back to you along with the completed data set, either through an Internet forum or distribution on CDROM. If you would prefer that your data not be distributed, please indicate that on the attached forms. Any information that you share with us will only be used for this exercise and will include a full acknowledgement of your contribution.

Attached you will find the two questionnaires along with their instructions and definitions for particular fields—one focuses on tiger information at the point scale, the other at the TCU scale. If at any time you need additional materials or have any questions, please send them to Andrea Heydlauff at aheydlauff@wcs.org, and she will facilitate your requests. You can complete the surveys either electronically (preferable) or on hardcopy. Please return the forms to Andrea Heydlauff at the Wildlife Conservation Society by June 30th 2004.

Our preference is to receive electronic copies of the form, which can be sent to:
aheydlauff@wcs.org

Alternatively you can mail hardcopies of the forms to:

Tiger Conservation Database
c/o Andrea L. Heydlauff
Wildlife Conservation Society
International Department
2300 Southern Blvd.
Bronx NY 10460 USA

Your timely assistance is much appreciated, and the information that you provide will be crucial to understanding the larger picture, and to see both our successes and challenges in our quest to secure a future for wild tigers.

On behalf of both our donor and conservation partners, as well as people everywhere concerned about tigers, we thank you in advance for your assistance and participation.

John Seidensticker
Chairman, Save The Tiger Fund and SNZP

Eric Dinerstein, WWF

Joshua Ginsberg, WCS

A1–2 TCU Questionnaire Instructions

Dear Tiger Researcher and Conservationist,

Thank you for agreeing to complete the TCU Questionnaire. Please fill out one of these survey forms for each TCU (or comparable area which you designate in China and Russia) for which you have information from the last 8 years. You need not have worked in the area personally to complete the data form below but you should have sufficient familiarity to answer the following questions. Please replicate the form as many times as necessary. You can complete the form either electronically (preferable) or on hardcopy. Please return the forms to Andrea Heydlauff at the Wildlife Conservation Society by June 30th, 2004.

These instructions and definitions are to simply clarify certain questions within the survey. Please use these definitions when answering the questions. If any question seems unclear, please send an e-mail to aheydaluff@wcs.org

Note that questions are deliberately designed not only to document current patterns and threats, but also to query potential threats and conservation measures in the future.

Instructions for Submission of TCU Questionnaire

Please provide your name, postal and electronic mail (e-mail) addresses and your phone number with applicable country codes. At your option, please also provide the name and addresses of your institutional affiliation. If you complete multiple forms, you need only provide your address and contact information on the first form. However for each new primary observer, please provide full name and contact information.

Forms can be completed by hand and mailed to:
Tiger Conservation Database
c/o Andrea Heydlauff
Wildlife Conservation Society
International Dept.
2300 Southern Blvd.
Bronx NY 10460 USA

To e-mail an electronic contribution to the FDTC (which we would prefer), e-mail the completed MS Excel data form to aheydlauff@wcs.org, writing your name, country, and date in the subject line of your e-mail message.

Definitions

Researcher Identification Information

Researcher You need not have worked in the area personally to complete the data form but you should have sufficient familiarity to answer the following questions.

Contact Information Please provide your full mailing address including all relevant postal codes for the researcher. Please also provide your phone number (with appropriate country code) and e-mail address.

Institutional Affiliation Any institutional affiliation you would like to recognize associated with your understanding in this TCU.

TCU Identification Number Identification that has been assigned to the Tiger Conservation Unit. Please refer to the map accompanying these instructions.

Marking area on the map If your tiger data does not refer to a defined TCU, please circle or mark with a circle or symbol the area on the map provided where your data correspond.

Section I. Status of Tigers

Scientific documentation A tiger has been "scientifically documented" if a standardized protocol for searching and observing tigers was followed. This includes camera-trapping, line transect surveys, and other standard field protocols for detecting tigers. Please indicate in the notes field the methods used and if published, the literature reference. Reports and other forms of grey literature are also useful.

Evidence of breeding Positive evidence of breeding includes evidence of cubs or finding a breeding den. Indicate the type of breeding evidence in the notes field.

Scientifically documented population estimate Scientific methods for estimating population estimates follow standardized protocols and are replicable. Please indicate the methods used and literature references if available.

Section II. Threats to Tigers

Severity Please indicate the level of severity of the threat to tiger survival using scores 0 through 3 according to the table below:

No effect on tigers	0
Small effect on density or distribution	1
Substantial effect on density or distribution, but local eradication unlikely	2
Serious effects, local eradication a possibility	3

Urgency Please indicate how urgent the threat is to the survival of the tiger using scores 0 through 3 according to the table below:

Will not happen in > 10 years	0
Could happen over 3–10 years	1
Could or will happen within 1–3 years	2
Threat is currently happening	3

Recovery time Please indicate how long in years it would take for tigers to recover form that particular threat if the threat was alleviated, using scores 0 through 3 according to the table below:

Immediate or < 1 year	0
1–10 years recovery	1
10–100 years recovery	2
100 + years or never	3

Percentage of TCU affected by threat: Please indicate how much of the TCU is currently affected by that particular threat using scores 0 through 3 according to the table below:

1–10%	0
10–25%	1
25–50%	2
> 50%	3

Probability of occurrence: If the threat is not occurring yet, estimate the probability that it will occur on a 0 – 1 scale (e.g. 0.5 indicates 50% chance that the threat will occur). If the threat is already occurring, indicate "1."

Section III. Conservation of Tigers

Conservation measures present: Please indicate using Y for yes and N for no if the particular conservation measure has been implemented within the TCU since 1995.

Effectiveness of conservation measures: Please circle the number that corresponds to how effective you believe these measures to have been. 1 is the lowest ranking of not effective at all—no difference made with respect to tiger conservation, 3 is a middle ranking some effectivness—some positive outcomes with respect to tiger conservation, 5 is the highest ranking of fully effective—meets all expectations with respect to tiger conservation.

Present in the near future If you indicated that the conservation measure was not present in the last 8 years, please can you indicate in the far right column if you believe that conservation measure will be present in the near future.

Protected Areas Please write in the name of the Protected Area and next to it, circle the number that best indicates how effective the Protected Areas has been in protecting tigers and tiger habitat.

Government Agency If a unit of government of your country is involved in tiger conservation within this particular TCU, please indicate in the space provided.

Species of conservation interest Please indicate any other species (from any taxa) that is found within this TCU in which there lies a conservation interest.

Section IV. Researchers collecting data on tigers within the TCU during the last 8 years

Please indicate whether you personally have worked in this TCU in the last 8 years and indicate the names, institutions, addresses, phone and fax numbers, and e-mails of other researchers who have worked in the TCU over the past 8 years as well.

Section V. Additional comments

Please feel free to add any additional information that you feel would be beneficial, as well as any additional comments you would like to share.

A 1–3 Tiger Conservation Unit (TCU) Survey

Name: ______________________ Date: ______________________

Postal address: ______________________

E-mail address: ______________________

Phone number: ______________________

Name of your institutional affiliation: ______________________

Postal address of your institutional affiliation: ______________________

____

Does this survey refer to a TCU? ____Yes ______No

If Yes, what is the TCU Identification number: ______________________
(refer to accompanying map of your region)

If No, indicate the area on the map and provide a name or number here:

____

(To fill out the rest of the questionnaire, please substitute '*TCU*' with '*specified area from the map*').

I. Status of Tigers

1. Has there been an **attempt** to scientifically document tigers in this TCU during the **last 8 years** (1995 – present)?

____ Yes ____ No ____ Don't Know

If you answered 'No' please skip to question #4

2. Have tigers been scientifically documented in this TCU in the **last 8 years**?

____ Yes ____ No ____ Don't Know

3. If yes, using what methods? (Please explain):

____

____

____

____

4. Is there any other documentation (besides scientific) of tigers present in the TCU in the **last 8 years**?

____ Yes ____ No

If yes, please explain:

____

____

____

____

5. Have tigers been scientifically documented in this TCU **since January 1, 2003**?

____ Yes ____ No ____ Don't Know

6. If Yes, using what methods? (If methods used are same as in question #3, write "same"):

____

____

____

____

7. Is there evidence of tigers breeding in this TCU during the **last 8 years**?

____ Yes ____ No ____ Don't Know

8. If Yes, what is that evidence of tigers breeding (check all that apply):

_____ Cubs Observed _____ Den Found _____ Pregnant Female Observed

_____ Observed Tigers Mating

9. Other (please explain):

____

____

____

____

10. Is there a **scientifically documented population estimate** for tigers in this TCU?

____ Yes ____ No ____ Don't Know

11. What is the estimated number of tigers in that population?

_____ 1 – 10 _____ 10 – 20 _____ 20 – 50 _____ 50 – 100 _____ more than 100

_____ Other _____ Don't Know

12. What scientific method was used to determine the population estimate? (Please explain):

III. Threats to Tigers

1. Please rank all the threats to tigers, which you believe apply to this TCU over the **last 8 years.** Rank their severity, urgency, etc based on the following criteria given beneath the table:

Threats	**Severity**	**Urgency**	**Recovery time**	**Percentage of TCU affected by threats**	**Probability of occurrence**
Directed hunting of tigers					
Incidental hunting of tigers					
Hunting of tiger prey					
Local trade in tiger parts					
Export of tiger parts to other areas					
Lack of legal protection					
Lack of enforcement					
Habitat degradation					
Habitat destruction					
Lack of connectivity					
Competition from other carnivores					
Low tiger population size					
Civil unrest					
Resource exploitation					
Disease					
Other:					
Other:					
Other:					

Severity of threat	
No effect on tigers	0
Small effect on density or distribution	1
Substantial effect on density or distribution, but local eradication unlikely	2
Serious effects, local eradication a possibility	3
Urgency of threat	
Will not happen in > 10 years	0
Could happen over 3–10 years	1
Could or will happen within 1–3 years	2
Threat is currently happening	3
Time it would take for tigers to recover from the threat	
Immediate or < 1 year	0
1–10 years recovery	1
10–100 years recovery	2
100 + years or never	3
Percentage of TCU affected by threat	
1–10%	0
10–25%	1
25–50%	2
> 50%	3
Probability of occurrence	0–1

IV. Conservation of Tigers

1. Please indicate the conservation measures which have been taken over the **last 8 years** in this TCU and rank their effectiveness; if the conservation measure does not currently exist, please indicate if you believe it might exist in the near future.

Present in last 8 years? Yes / No	**Conservation Measures**	**Effectiveness of conservation measures** Not effective				Fully effective	**If not present will it be in the near future? Yes / No**
	Monitoring of tigers in the field	1	2	3	4	5	
	Monitoring of prey populations	1	2	3	4	5	
	Monitoring of trade in tiger parts	1	2	3	4	5	
	New laws/policies regarding tigers	1	2	3	4	5	
	Anti-poaching patrols	1	2	3	4	5	
	Anti-trafficking enforcement	1	2	3	4	5	
	Enforcement of protected area policies	1	2	3	4	5	
	Training of protected area staff	1	2	3	4	5	
	Enforcement of existing laws regarding tigers	1	2	3	4	5	
	Provisioning or monetary support to protected area staff	1	2	3	4	5	
	New / upgraded protected area	1	2	3	4	5	
	Habitat restoration	1	2	3	4	5	
	Habitat enhancement	1	2	3	4	5	
	Education of local people	1	2	3	4	5	
	Education of schoolchildren	1	2	3	4	5	
	Translocation of local people out of protected area	1	2	3	4	5	
	Local publicity about tigers	1	2	3	4	5	
	Ecotourism ventures	1	2	3	4	5	
	Reintroduction of tigers	1	2	3	4	5	
	Captive breeding facility	1	2	3	4	5	
	Compensation programs:	1	2	3	4	5	
	Conflict management/mitigation	1	2	3	4	5	
	Other:	1	2	3	4	5	
	Other:	1	2	3	4	5	
	Other:	1	2	3	4	5	

2. Name all protected areas which occur on some part of this TCU and evaluate the effectiveness of the actual security (not the legal protection) which that protected area affords:

Protected Area Name	**Effectiveness of Actual Protection**					
	Not Effective			Fully Effective		
____________	1	2	3	4	5	Don't Know
____________	1	2	3	4	5	Don't Know
____________	1	2	3	4	5	Don't Know

3. What government agencies, if any, are responsible for tiger conservation in this TCU?

____

____

____

____

4. What other species of conservation interest are present in this TCU (give common name)?

____

____

____

____

IV. Researchers collecting information on tigers in the TCU during the last 8 years.

1. Have you worked in this TCU during the **last 8 years**? ______Yes ______ No

2. Who else has worked on tigers in this TCU during the **last 8 years**?

Researcher #1

Name: ______________________________

Institution: ______________________________

Address: ______________________________

Phone: Fax: E-mail: ______________________________

Researcher #2

Name:

Institution:

Address:

Phone: Fax: E-mail:

Researcher #3

Name:

Institution:

Address:

Phone: Fax: E-mail:

V. Additional Comments:

A1–4 TCD Survey Instructions

May 3rd 2004

Dear Tiger Researcher and Conservationist:

Thank you for agreeing to contribute to the Tiger Conservation Database (TCD) by filling out the TCD Survey. The TCD is a geographic database of localities (points) where scientists have made an effort to locate, or an attempt to locate, tigers. The basic data item is the point observation, defined as below, to which this questionnaire pertains. These instructions and definitions are to simply clarify certain questions within the survey. Please use these definitions when answering the questions. If you have any questions regarding the data form or the database, please send an e-mail to Andrea Heydlauff at aheydlauff@wcs.org.

Instructions for Submission of Tiger Observations to the TCD

Please provide your name, postal and electronic mail (e-mail) addresses and your phone number with applicable country codes. At your option, please also provide the name and addresses of your institutional affiliation. If you complete multiple forms, you need only provide your address and contact information on the first form. However for each new primary observer, please provide full name and contact information. Every piece of information you provide will be attributed with your name and institution in the database. If you do not wish your information shared broadly with the tiger community for any reason, please indicate so on the form.

To e-mail an electronic contribution to the TCD (which we would prefer), e-mail the completed MS Excel data form to aheydlauff@wcs.org, writing your name, country, and date in the subject line of your e-mail message.

Forms can also be completed by hand and mailed to:

Tiger Conservation Database
c/o Andrea Heydlauff
Wildlife Conservation Society
International Dept.
2300 Southern Blvd.
Bronx NY 10460 USA

Thank you for your help.

Definition of a point observation

For the purposes of the Fundamental Database of Tiger Conservation a "point observation" is defined as the collection of all observations made to locate a tiger within a 3-month period and with a circular area of 20 km radius of the location center, whether or not a tiger was sighted. Tigers do not need to be observed for the observation to be recorded in the database; only that a tiger or tiger sign has been searched for using standard scientific methods, as described below. All individual observations made within the 3-month period and within 20 km of the center coordinates should be compiled as a single observation in the database. The point observation represents the basic analytical unit of the database.

Data Sheet Identification Information

Researcher The person identified should be the primary observer of all the observations recorded on the data sheet. If you are reporting observations made by others, they should all be labeled as “reports” under observation method.

Institutional Affiliation Any institutional affiliation you would like to recognize. Each institution will receive an acknowledgement letter recognizing your contribution to the database.

Contact Information Please provide full mailing address including all relevant postal codes for the researcher and any institutions and funding sources you designate. Please also provide your phone number with appropriate country code and e-mail address.

TCD Database Fields

Space for use of Researcher This field is to allow space for any internal coding systems used by the researcher. This field is optional. This information will not be entered in the FDTC.

Dates of first and last observation For observations compiled over a period of time not exceeding 3 months, the dates of the first and last observation should be recorded dd/mm/yyyy format. If only observation is made on a single day, then the dates of the first and last observation should be the same.

Estimated number of days in active search During the review period, how many days were spent actively searching for tigers using the given observation methods. This field is meant as an index of search effort.

Longitude and Latitude Recall that each point observation represents all observations with a 20 km radius of the center specified by the longitude and latitude. Longitude and latitude should be expressed in decimal degrees to at least two decimal places and using the standard positive/negative conventions to indicate the appropriate hemisphere. The conversion from Degrees-Minutes-Seconds to Decimal Degrees is to calculate DD = D + M/60 + S/3600. Since tigers in the wild are only found in the Eastern hemisphere, all longitude values should be positive between 0 – 180. Latitudes in the northern hemisphere should be signed positive, and latitudes in the southern hemisphere should be signed negative. For example, a point observation centered in Bukit Barisan Selatan National Park, in Sumatra south of the Equator, would be indicated as longitude = 104.51, latitude = -5.84. If you know the location of your point observation in some other map projection coordinates (for example, UTM), contact your local GIS expert or tigerdata@wcs.org for assistance to convert your coordinates to latitude/longitude.

Estimated Accuracy of Position The estimated accuracy of the position information in kilometers is a function of your method of identifying the location. Some location methods have standardized accuracies (e.g. non differential GPS prior to June 2000 = 0.1 km, differential GPS and non-differential GPS after June 2000 = 0.01 km), others need to be estimated by you. The researcher should estimate maximum suspected error of the location information.

Evidence of Tiger Presence Recall that the FDTC records not only locations where tigers have been observed, but also locations where tigers have been searched for using standard scientific techniques, but not found. This field is filled with a binary code, 1= tiger present; 0=no tiger observed. No tiger observed does not necessarily indicate a true absence, just the lack of detection by you at that particular time and place.

Evidence of Breeding Is there any evidence of breeding? 1 = Yes, 0 = No. Positive evidence of breeding includes evidence of cubs or finding a breeding den. Indicate the type of breeding evidence in the notes field.

Observation Method Tigers can be observed in a variety of different ways, including direct sighting or photography, telemetric methods after fitting tigers with the an appropriate device, indirect evidence like scat or tracks or a kill, and reports from other reliable observers. Standard observation methods are specified on the data form and defined below. In each case, "the researcher" refers to the primary observer who should be identified at the top of the data form. If one or more observation methods are used, indicate the approximate number of observations with each method that applies. However if confirmed observations are made with a more reliable method (e.g. photo), then the details of less reliable methods (e.g. second hand reports) can be omitted. Note observation method types are ordered in approximate order of reliability. If some other observation method is used, check the "other" box and provide a full definition on the back of the form or in an additional note.

Method Name	**Definition**
First hand Sighting	The researcher personally saw a tiger and can vouch for its proper identification.
Radiotelemetry	The researcher placed a radiotelemetry or satellite collar on the tiger and followed it using standard techniques.
Photograph	The researcher obtained a photograph of the tiger, for example with a camera trap.
Tracks	The researcher observed one or more tiger tracks and can vouch for their proper identification.
Scat	The researcher observed one or more tiger scats and can vouch for their proper identification.
Heard	The researcher personally heard a tiger and can vouch for its proper identification.
Tiger Mortality	The researcher observed the remains of a tiger and can vouch for their proper identification. The type of remains and putative cause is noted in the Observation Method Table.
Tiger Kill	The researcher observed the remains of an animal killed by a tiger and can vouch for kill being made by a tiger.
Report (high confidence)	The researcher was told that another person had observed a tiger in a reliable way and the researcher places high confidence in the veracity of that

Report (low confidence)	The researcher was told that another person had observed a tiger in a reliable way, but the researcher is unsure about of the reliability of the observation.
Other	The tiger was observed in some other manner which is described fully by the researcher.

Location Method Similarly there are a variety of standard methods for determining your geographic location. If you use some other method of locating your observation, please check the "other" box and provide a full definition.

Method Name	**Definition**
Non-differential GPS	The researcher used a global positioning system device without differential correction. Prior to June 2000, the accuracy of such a device was typically 0.1 km. After June 2000, the accuracy of such a device is typically 0.01 km.
Differential GPS	The researcher used a global positioning system device with differential correction.
Satellite collar	The researcher fitted the tiger with a satellite collar
Telemetry Fix	The researcher fitted the tiger with a VHS type telemetry collar.
Map and Compass	The researcher used a map and compass in the field.
GIS	The researcher used a geographic information system.
Dead Reckoning	The researcher used a map without a compass and after returning from the field.
Second hand Report	The researcher was told where the tiger was observed by the person who made the observation.
Third hand Report	The researcher was told where the tiger was observed by the some one other than the person who made the observation.
Other	The researcher used a different method which is fully defined in a separate note.

Notes: Any additional note about the observation that you would like to include about this particular observation. Additional information might be about the number of tigers you believe you observed at the point, the sex and ages of the tiger(s) observed, the conservation status of the tigers, comments about the reliability of the observation, publications or reports resulting from this observation, or any other information you would assist someone else in interpreting your observation. If necessary, attach additional pages of notes, clearly labeling each observation in the note field.

Appendix 2 Scores Used to Prioritize TCLs

Threat scores, evidence of tiger breeding, scientific population estimates (first if there was one, and then the range of what that estimate was), and overall conservation effectiveness scores, per TCU. -888 indicates missing data and -999 indicates a response of "do not know" or "unknown."

Locator ID	Country	TCU 1.0 #	Threat Score	Evidence of tiger breeding	Scientific population estimate	Population estimate	Overall conservation effectiveness
1	Bangladesh	No #	-888	1	1	-888	-888
2	Bangladesh	No #	65	1	1	100	38
3	Bangladesh	IS017	441	-888	0	-888	26
4	Bangladesh	No #	426	-888	0	-888	26
5	Bangladesh	No #	41.6	1	1	100	26.5
6	Bhutan	No #	-888	1	1	100	63
12	China	No #	70.2	0	0	5	35.5
13	China	No #	459	0	1	-999	21.5
14	China	No #	776	1	0	-999	56
17	India	IS055	136	1	1	100	60
19	India	IS020	128	1	1	100	46
20	India	IS018	247	1	1	100	27
21	India	IS016	118	1	1	100	34
24	India	IS025	156	1	1	100	44
25	India	IS044	123	1	1	100	45
26	India	IS059	50.2	1	0	75	37
27	India	IS039	99.8	1	1	100	38
28	India	IS09	139.6	1	1	-999	52
29	India	No #	0	1	0	-888	41
31	Indonesia	SA022	119	1	1	100	37
32	Indonesia	SA031	259.5	1	1	35	46
33	Lao PDR	IC021	339.6	0	0	5	39
34	Lao PDR	Nam Et Phou Louey	198.3	0	1	15	35
36	Lao PDR	No #	132.6	0	0	-888	16.5
37	Lao PDR	ICD40	178	-888	0	-888	10
39	Nepal/India	IS005	269.2	0	0	-888	20.5
42	Nepal/India	IS003	22.8	1	1	5	21
43	Nepal/India	IS008	324.3	0	0	-888	20.5
44	Nepal/India	IS007	274.2	0	0	-888	20.5
46	Malaysia	No #	274.2	1	1	75	72
48	Malaysia	No #	6	1	1	15	9
49	Malaysia	No #	-888	-888	0	-888	7
50	Malaysia	SA011	-888	0	1	5	2
51	Malaysia	SA003	283	0	1	15	2
52	Malaysia	SA004	283	0	1	15	2
53	Malaysia	SA005	283	0	1	15	2
54	Malaysia	SA006	283	0	1	15	2
55	Malaysia	SA007	283	0	1	15	2
56	Malaysia	SA008	283	0	1	15	2
57	Malaysia	SA009	283	0	1	15	2

Locator ID	Country	TCU 1.0 #	Threat Score	Evidence of tiger breeding	Scientific population estimate	Population estimate	Overall conservation effectiveness
58	Malaysia	SA010	283	0	1	15	2
59	Malaysia	SA012	283	0	1	15	2
60	Malaysia	SA013	283	0	1	15	2
63	Malaysia	SA016	283	0	1	15	2
65	Myanmar	IC002	489	-888	1	15	29
68	Myanmar	IC003	489	1	0	-888	17
69	Myanmar	IC013	543	0	0	-888	9.5
71	India	No #	298	1	1	75	59
76	Russia	No #	109.8	1	1	15	36
77	Russia	No #	363.3	1	1	35	-888
78	Russia	No #	92.2	1	-888	100	42.5
79	Russia	No #	113	1	1	75	49.5
80	Russia	No #	0	1	1	5	31
81	Russia	No #	229.8	1	1	100	43.5
82	Russia	No #	183.1	1	1	35	49.5
85	Thailand	IC063	276	0	1	5	38
87	Thailand	IC101	180	1	1	5	22.5
89	Vietnam	IC031	345	-888	0	-888	18.5
90	Vietnam	IC032	345	-888	0	-888	18.5
91	Vietnam	IC033	345	-888	0	-888	18.5
92	Vietnam	IC040	305	-888	0	-888	17
93	Vietnam	IC046	280	-888	0	-888	26
95	Vietnam	IC052	280	0	0	-888	26
96	Vietnam	IC053	280	-888	0	-888	26
97	Indonesia	SA026	63	1	1	-888	12
98	Nepal	No #	-888	1	1	35	39
100	India	IS001	126.6	1	0	-888	47.5
103	India	TCL2.0 16	194.6	-888	0	5	45
104	Indonesia	TCL2.0 64	95	1	0	-888	14
7, 8	Cambodia	IC067	230.8	1	0	5	35
9, 11	Cambodia	IC055	284.5	0	0	5	28.5
10, 86	Thailand	IC064	293.5	0	0	5	25.5
15, 23	India	ISO28	273	1	1	100	33
16, 18	India	ISO31	230	1	1	100	35
22, 99	India	IS010	139.6	1	1	-999	39
30, 38	Indonesia	SA020	69.4	1	1	100	18
35, 94	Vietnam	IC049	190	0	0	-888	21
40, 73, 75, 102	Nepal	IS004	58.55	1	1	75	52.2
41, 72	Nepal	IS006	11.4	1	1	75	78
45, 74, 101	Nepal	IS002	106.4	1	1	35	55.5
47, 88	Thailand	SA001	1.5	1	1	75	36
61, 62	Malaysia	SA015	283	0	1	15	2
64, 67,70	Myanmar	IC001	115.3	1	1	35	34.5
83, 66, 84	Thailand	IC014	206.4	1	1	5	23

Appendix 3–1 Contributors to the TCU and TCD Questionaires

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Banerjee	Lt. Col. S.R.	WWF-India Secretariat (State Director, WWF-India, West Bengal State Office)	172-B Lodi Estate, New Delhi - 11003	IS09, IS01, West Bengal. Sunderban Biosphere Reserve and North Bengal: Neora Valley N.P. and Jaldapara WLS
Brunner	Jake	Conservation International	Cambodia	IC055, IC0 64, and IC070
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Dunishenko	Yuri	VINNIOZ	Russia	1 TCU for RFE
Ellis	Susie	Conservation International	CI - Indonesia	1 TCU and 1 TCD
Eve	Roland	WWF-Lao	WWF Lao Program Office, PO Box 7871, Vientiane, Lao PDR	
Goodrich	John	WCS	2300 Southern Blvd., Bronx, NY 10460	Russia, Sikhote-Alin Zapovednik and adjoining lands

Last Name	First Name	Affiliation	Address of affiliation	TCU # or area to which questionnaire pertains
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Johnsingh	A.J.T.	Wildlife Institute of India	Post Box # 18, Chandrabani,Dehra Dun – 248 001, Uttaranchal, India	IS059
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Kawanishi and Sunquist	Kae, Melvin	University of Florida, Department of Wildlife Ecology and Conservation	P. O. Box 110430, Gainesville, FL 32611-0430	SA001and Taman Negara
Keavuth	Huy	WWF-Cambodia	28, St. 9, Tonle Basac, PO Box 2467	IC055
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Khan	Mohammed	IUCN Asian Rhino Specialist Group	Malaysia	1 TCU form
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Lee, Gorog, Winarni, Wijayanto, Nugroho, and Aslan	Robert, Antonia, Nurul, Untung, Dwi, Aslan	Wildlife Conservation Society-Indonesia Program	Jl. Pangrango 8. PO Box 311. Bogor 16003, Indonesia	SA031
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Last Name	First Name	Affiliation	Address of affiliation	TCU # or area to which questionnaire pertains
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Muntifering	Jeff R.	Round River Conservation Studies	404 N 300 W Suite 102, Salt Lake City, Utah, 84103	South Central China (primarily northern Hunan province and central Jiangxi province)
Myanmar WCS Tiger Team		WCS - Myanmar	WCS Myanmar program, Building C-3, Aye Yeik Mon 1st Street. War 3 Hlaing Township, Yangon, Myanmar	IC001, IC002, IC003, IC013, IC014
Myint	U Than	WCS - Myanmar	WCS Myanmar program, Building C-3, Aye Yeik Mon 1st Street. War 3 Hlaing Township, Yangon, Myanmar	IC001, IC002, IC003, IC013, IC015
Namgay	Kinzang	WWF (Country Director)	Chubachu, GPO Thimphu, PO Box 210, Thimphu, Bhutan	1 TCU

Last Name	First Name	Affiliation	Address of affiliation	TCU # or area to which questionnaire pertains
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Patnaik	Mr. Saroj	WWF (Chairman WWF-India Orissa State Office and ex Chief Wildlife Warden, Govt. of Orissa)	India	India
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Purastuti	Elisabet	WWF (GIS officer)	Indonesia	Indonesia
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Rahman	Mowdudur	Center for Coastal Environmental Conservation	Bangladesh	Sundarbans, Bangladesh
Rahman and Faruque	Shamsur and Anwar	Government of the People's Republic of Bangladesh, forest Department	Forest Department,Bana Bhaban, Mohakhali, Dhaka-1212, Bangladesh	Sundarbans, Bangladesh
Ramesh	K	Wildlife Institute of India, Senior Research Fellow, Terai Arc Tiger Conservation Landscape Project	India	India

Last Name	First Name	Affiliation	Address of affiliation	TCU # or area to which questionnaire pertains
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Royal Shukla Phanta Wildlife Reserve		Department of National Parks and Wildlife Conservation	P.O.Box: 860, Babarmahal, Kathmandu, Nepal	IS002
Salkina	Galina	Lazovsky reserve, Tiger Protect Society	56, Centrallnaya, Lazo, Primorsky Region 692980, Russia	Lazovsky, Olginsky, Tchuguevsky and Partizansky Districts of Primorye Region
Sangita	Dr.	WWF	India	India
Sawarkar	V.B.	Former Director Wildlife Institute of India	India	India
Schmitt	Kalus	CWRP	Cambodia	3 TCUs and 3 TCDs
Sen	P.K.	WWF-India	172-B, Lodi Estate, New Delhi - 110003	India
Shaharrudin, Laidlaw, Lynam and Gumal	Wan, Ruth, Antony and Melvin	DWNP Malaysia ; WCS – International Programs	DWNP, 10 Jalan Cheras, Kuala Lumpur, West Malaysia; WCS – International Program, 2300 Southern Blvd, Bronx NY 10460 USA	SA003, SA004, SA005, SA06, SA007, SA008, SA009, SA010, SA011, SA012, SA013, SA015, SA016
Shepherd	Chris	TRAFFIC	SE Asia	
Shrestha	Mahendra K.	University of Minnesota; Dept. of Nat Parks, Nepal	1980 Folwell Ave., 200 Hodson Hall, St. Paul, MN 55108	IS002, IS003, IS004, IS005, IS006, IS007, IS008
Shrestha	Mahendra K.	University of Minnesota Fisheries and Wildlife Conservation Biology	Nepal	Nepal
Simchareon	Saksit	Dept. of NP, Wildlife	Thailand	Thailand
Simms	Anthony	Conservation International	PO Box 1356 Phnom Penh Cambodia	IC067
Simms	Anthony	Conservation International	Cambodia	Cambodia

Last Name	First Name	Affiliation	Address of affiliation	TCU # or area to which questionnaire pertains
Smith	Dr. James LD	University of Minnesota Fisheries and Wildlife Conservation Biology	University of Minnesota	Nepal
Steinmetz	Robert	World Wide Fund for Nature-Thailand Program Office	WWF-Thailand, PO Box 4, Asian Institute of Technology, Klong Luang, Patumthani, 12120, Thailand	IC049
Strien and Foose	Nico Van and Thomas J	International Rhino Foundation		Sent IRF datasets
Sunarto and Brunner	Sunarto and Jake	Comp 1 Kerinci Seblat ICDP & Conservation International Indonesia	Conservation International Indonesia, Jl. Pejaten Barat No 16A, Kemang, Jakarta 12550, Indonesia	SA020 and focused in nine timber concession areas bordering Kerinci Seblat National Park and Batang Gadis National Park
Tenzin	Chado	WWF Bhutan Tiger Program	Chubachu, GPO Thimphu, PO Box 210, Thimphu	Bhutan
Than	U Tin	WWF -Thailand, GIS	WWF-Thailand, PO Box 4, Asian Institute of Technology, Klong Luang, Patumthani, 12120, Thailand	IC049
Wahab	Ahmad Zafir Abdul	WWF Malaysia	49, Jalan SS23/15,Taman SEA, 47400, Petaling Jaya, Selangor, Malaysia	Jerangau and Ulu Muda Forest Reserve
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Weiler	Hunter	Fauna & Flora International / Cat Action Treasury		IC055, IC0 64, and IC067
Yonzon	Pralad	Resources Himalaya	Nepal	Nepal
Zafir and Wahab	Ahmad and Abdul	WWF - Malaysia (Tiger Program)	49, Jalan SS23/15,Taman SEA, 47400, Petaling Jaya, Selangor, Malaysia	Malaysia
Zhang and Li	Endi and Eve	WCS China	Wildlife Conservation Society- China Program,c/o East China Normal University, Shanghai 200062, China	Hunchin, Jilin Province

Last Name	First Name	Affiliation	Address of affiliation	TCU # or area to which questionnaire pertains
Zubtsov	Sergei	Inspection Tiger	Russia	Russian Far East

Appendix 3–2 Other Contributing Sources to the Tiger Database

Scientific Publications, Grey Literature, and Personal Observations/Communications—Collected & Collated between May 2004 and December 2005

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Center for Wildlife Studies

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Dahmer, Tom. TCL Field review; personal communication.

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Khan, Munjurul Hannan. TCL field review; personal communication.

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Lynam, Tony. TCL field review; personal communication.

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Matyr, Debbie. FFI. TCL Field review; personal communication.

Mavalwala, Mahernosh. Nagpur, India. TCL Field review; personal communication.

McDougal, Charles. Nepal. TCL field review; personal communication.

McGregor, Tessa. Russia far east. TCL field review; personal communication.

Menon, Vivek. Wildlife Institute of India. TCL field review; personal communication.

Minnesota Zoo Foundation

Miquelle, Dale. TCL field review; personal communication.

Mitra, Sangita. WWF India. TCL Field review; personal communication.

Mohanty, Biswajit. Secretary, Wildlife Society of Orissa - TCL field review; personal communication.

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Purastuti, Elisabet, WWF Indonesia. TCL field review; personal communication.

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Rahman, Mowdudur. CCEC Bangladesh. TCL field review; personal communication.

Ranthambhore Foundation

Respess, Rebecca. WildAid. TCL field review; personal communication.

Robichaud, William. Laos. TCL field review; personal communication.

Round, Philip D. TCL field review; personal communication.

Salkina, Galina. Russia. TCL field review; personal communication.

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University of Florida

University of Minnesota

USAID

WCS

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Zoological Society of London

Appendix 4 What We Know About TCUs

Identified in 1997's Framework Document as 'Immediate Surveys'

TCU's identified in TCU1.0 as "Immediate survey's needed"

Indian subcontinent			
Immediate survey units	TCU1.0 ID	TCU's for which we have questionnaire data	Attempt to scientifically document tigers?
	IS016	Yes	Yes
	IS025	Yes	Yes
	IC070		
	IS029		
Tiger population status needed			
	IS010	Yes	Yes
	IS031	Yes	Yes
	IS055	Yes	Yes
	IS059	Yes	No
	IS052		
	IS027		
Indochina immediate survey units			
	IC001	Yes	Yes
	IC004		
	IC024		
	IC023		
	IC012		
	IC070		
Southeast Asia immediate survey units			
Tiger population status needed			
	SA026	Yes	Yes
	SA018		
	SA027		
	SA023		

Appendix 5 Detailed Description of Methods for Land Cover Creation

Creating the Asia polygons land cover map for delineating the Tiger Conservation Landscapes (TCLs) was mostly an exercise in data integration. Yet, because of considerable variation in formats, projections, spatial resolution, and land cover classification systems, this process was very time-consuming.

In the initial processing, all data were projected to a Lambert Azimuthal Equal Area projection. In the next step, the data attribute tables were expanded to include our major land cover types, as well as a unique identifier for each of the sources and a unique numerical identifier for each of the original habitat types (Table A5.1).

After expanding the attributes, we rasterized all polygon data using the unique habitat identifiers, to produce ArcInfo grids with a 1-km cell size. Similarly, we imported all raster datasets into ArcInfo grid format and resampled the grids to a 1-km resolution. All resulting raster data sets were combined into a single land cover grid. After the integration the original data attribute tables were joined based on the unique habitat identified. This procedure allowed us to retain all original information even after integrating all data into a single land cover grid. The method also allowed for subsequent addition of data sets as they became available.

Based on group discussions, suitability codes (structural land cover and marginal dispersal zone) were created for each of the major habitat categories and also added into the attribute table. These suitability codes were the basis for the TCL delineation and were also used in the TCL classification.

Identifier	Original land cover	Major land cover type	Source	Suitability
1	Mangrove	Mangrove	Terai Arc	structural land cover
2	Water	Water	Terai Arc	dispersal zone
3	Settlement	Agriculture	Terai Arc	dispersal zone
4	Degraded_scrub	Degraded Scrub	Terai Arc	dispersal zone
5	Exposed_surface	Barren	Terai Arc	dispersal zone
6	Short_grass	Grassland	Terai Arc	structural land cover
7	High_desnity_forest	Forest	Terai Arc	structural land cover
8	Low_density_forest	Forest	Terai Arc	structural land cover
9	Tall_grass	Grassland	Terai Arc	structural land cover
10	Sub Alpine Conifer	Evergreen	Myanmar forest cover	dispersal zone
11	Montane Wet Temper	Evergreen	Myanmar forest cover	structural land cover
12	Sub Tropical Lowland	Evergreen	Myanmar forest cover	structural land cover
13	Sub Tropical Forest	Evergreen	Myanmar forest cover	structural land cover
14	Semi Evergreen Forest	Evergreen	Myanmar forest cover	structural land cover
15	Dry Dipterocarp Forest	Deciduous	Myanmar forest cover	structural land cover
16	Tropical Moist Deciduous	Deciduous	Myanmar forest cover	structural land cover
17	Montane Deciduous	Deciduous	Myanmar forest cover	structural land cover
18	Dry Deciduous Forest	Deciduous	Myanmar forest cover	structural land cover
19	Sub Tropical Dry Evergreen	Evergreen	Myanmar forest cover	structural land cover
20	Tropical Montane Evergreen	Evergreen	Myanmar forest cover	structural land cover
21	Tropical Wet Evergreen	Evergreen	Myanmar forest cover	structural land cover
22	Thorn Scrub Forest	Scrub	Myanmar forest cover	dispersal zone
23	Mangrove	Mangrove	Myanmar forest cover	structural land cover
24	Freshwater Swamp	Swamp or Inundated	Myanmar forest cover	dispersal zone
25	Evergreen, highcover forest	Evergreen	Mekong river basin	structural land cover
26	Evergreen, med-low forest	Evergreen	Mekong river basin	structural land cover
27	Evergreen_mosaic	Evergreen	Mekong river basin	structural land cover
28	Mixed(evg&deci)high forest	Mixed Forest	Mekong river basin	structural land cover
29	Mixed(eveg&deci)medium forest	Mixed Forest	Mekong river basin	structural land cover
30	Mixed_mosaic forest	Mixed Forest	Mekong river basin	structural land cover
31	Deciduous forest	Deciduous	Mekong river basin	structural land cover
32	Deciduous_mosaic	Deciduous	Mekong river basin	structural land cover
33	Regrowth	Degraded Forest	Mekong river basin	structural land cover
34	Regrowth, inundated	Swamp or Inundated	Mekong river basin	dispersal zone
35	Innundated	Swamp or Inundated	Mekong river basin	dispersal zone
36	Mangrove	Mangrove	Mekong river basin	structural land cover
37	Plantation	Plantation	Mekong river basin	dispersal zone
38	Innundated_mosaic	Swamp or Inundated	Mekong river basin	dispersal zone
39	Wood_&_shrubland	Scrub	Mekong river basin	dispersal zone
40	Grassland	Grassland	Mekong river basin	structural land cover
41	Bamboo	Bamboo	Mekong river basin	dispersal zone
42	Wood_&_shrubland	Scrub	Mekong river basin	dispersal zone
43	Wood_&_shrubland	Swamp or Inundated	Mekong river basin	dispersal zone
44	Cropping mosaic	Agriculture	Mekong river basin	dispersal zone
45	Cropping_mosaic	Agriculture	Mekong river basin	dispersal zone
46	Agricultural_land	Agriculture	Mekong river basin	dispersal zone
47	Barrenland	Barren	Mekong river basin	dispersal zone
48	Rocks	Barren	Mekong river basin	dispersal zone
49	Urban_&_builtup	Urban Settlement	Mekong river basin	dispersal zone

Table A 5.1 Survey and Restoration Area Prioritization

Identifier	Original land cover	Major land cover type	Source	Suitability
50	Water	Water	Mekong river basin	dispersal zone
51	Wetland	Wetland	Mekong river basin	dispersal zone
52	Dense_forest	Forest	Central Truong Son	structural land cover
53	Grass	Agriculture	Central Truong Son	structural land cover
54	Water	Water	Central Truong Son	dispersal zone
55	Degraded_forest	Degraded Forest	Central Truong Son	structural land cover
56	Scrub	Scrub	Central Truong Son	dispersal zone
57	Water	Water	Lampung, Sumatra	dispersal zone
58	Ecotourism area	Grassland	Lampung, Sumatra	structural land cover
59	Coffee, Cacao	Plantation	Lampung, Sumatra	dispersal zone
60	Coffee, dry land	Agriculture	Lampung, Sumatra	dispersal zone
61	Coffee, patchouli	Agriculture	Lampung, Sumatra	dispersal zone
62	Coffee/cinnamon plantation	Plantation	Lampung, Sumatra	dispersal zone
63	Coffee, clove, pepper	Plantation	Lampung, Sumatra	dispersal zone
64	Coffee, pepper, clove	Plantation	Lampung, Sumatra	dispersal zone
65	Coffee,pepper, patcouli	Plantation	Lampung, Sumatra	dispersal zone
66	Coffee, pepper, shrub	Plantation	Lampung, Sumatra	dispersal zone
67	Coffee, vegetables	Agriculture	Lampung, Sumatra	dispersal zone
68	Dammar/Resin/Shore	Agriculture	Lampung, Sumatra	dispersal zone
69	Dammar/Resin/Shore	Agriculture	Lampung, Sumatra	dispersal zone
70	Dense forest	Forest	Lampung, Sumatra	structural land cover
71	Imperata grass	Grassland	Lampung, Sumatra	structural land cover
72	Imperata grass	Grassland	Lampung, Sumatra	structural land cover
73	Sawah/Paddy Field	Agriculture	Lampung, Sumatra	dispersal zone
74	Secondary Forest	Degraded Forest	Lampung, Sumatra	structural land cover
75	Secondary Forest	Degraded Forest	Lampung, Sumatra	structural land cover
76	Shrub, coffee	Plantation	Lampung, Sumatra	dispersal zone
77	Shrub, coffee, pepper	Plantation	Lampung, Sumatra	dispersal zone
78	Shrub, Perennial Crop	Agriculture	Lampung, Sumatra	dispersal zone
79	Forest	Forest	Tesso Nilo	structural land cover
80	Grass	Grassland	Tesso Nilo	structural land cover
81	Water Body	Water	Tesso Nilo	dispersal zone
82	Settlement	Urban Settlement	Tesso Nilo	dispersal zone
83	Degraded Forest	Degraded Forest	Tesso Nilo	structural land cover
84	Accacia	Plantation	Tesso Nilo	dispersal zone
85	Cleared	Barren	Tesso Nilo	dispersal zone
86	Cleared, for Sawit	Barren	Tesso Nilo	dispersal zone
87	Cleared	Barren	Tesso Nilo	dispersal zone
88	Coconut	Plantation	Tesso Nilo	dispersal zone
89	Factory	Urban Settlement	Tesso Nilo	dispersal zone
90	Mix Agriculture	Agriculture	Tesso Nilo	dispersal zone
91	Mix Garden	Agriculture	Tesso Nilo	dispersal zone
92	Oil Mine	Mining/Industry	Tesso Nilo	dispersal zone
93	Paddy Field	Agriculture	Tesso Nilo	dispersal zone
94	Palm Oil Plantation	Plantation	Tesso Nilo	dispersal zone
95	Rubber Plantation	Plantation	Tesso Nilo	dispersal zone
96	Shrub	Scrub	Tesso Nilo	dispersal zone
97	Town	Urban Settlement	Tesso Nilo	dispersal zone
98	Mangrove Forest	Mangrove	Sumatra	structural land cover
99	Plantation	Plantation	Sumatra	dispersal zone

Table A 5.1 (*continued*) Survey and Restoration Area Prioritization

Identifier	Original land cover	Major land cover type	Source	Suitability
100	Water Body	Water	Sumatra	dispersal zone
101	Settlement	Urban Settlement	Sumatra	dispersal zone
102	Swamp Forest	Swamp or Inundated	Sumatra	structural land cover
103	Highland Forest	Forest	Sumatra	structural land cover
104	Lowland Forest	Forest	Sumatra	structural land cover
105	Unproductive Dry	Barren	Sumatra	dispersal zone
106	Unproductive Dry	Barren	Sumatra	dispersal zone
107	Bare Soil	Barren	Sumatra	dispersal zone
108	Transmigration site	Transmigration Site	Sumatra	dispersal zone
109	Secondary Mangrove	Mangrove	Sumatra	structural land cover
110	Secondary Swamp	Swamp or Inundated	Sumatra	dispersal zone
111	Swampy Shruby	Swamp or Inundated	Sumatra	dispersal zone
112	Dry Land Agriculture	Agriculture	Sumatra	dispersal zone
113	Dry Land Agriculture	Agriculture	Sumatra	dispersal zone
114	Swamp	Swamp or Inundated	Sumatra	dispersal zone
115	Rice Field	Agriculture	Sumatra	dispersal zone
116	Fish Pond	Water	Sumatra	dispersal zone
117	Transmigration Site	Transmigration Site	Sumatra	dispersal zone
118	Mining	Mining/Industry	Sumatra	dispersal zone
119	Transmigration site	Transmigration Site	Sumatra	dispersal zone
120	Agricultural field	Agriculture	Russiona Far East	dispersal zone
121	Deciduous broad-leaf	Deciduous	Russiona Far East	structural land cover
122	Deciduous small-leaf	Deciduous	Russiona Far East	structural land cover
123	Deciduous Valley forest	Deciduous	Russiona Far East	structural land cover
124	Korean pine forest	Evergreen	Russiona Far East	structural land cover
125	Larch forests (mixed)	Mixed Forest	Russiona Far East	structural land cover
126	Young forest	Degraded Forest	Russiona Far East	dispersal zone
127	Spruce fir forest	Evergreen	Russiona Far East	structural land cover
128	Sparse forest	Degraded Forest	Russiona Far East	dispersal zone
129	Meadows	Grassland	Russiona Far East	structural land cover
130	Swamp/coastal wetland	Swamp or Inundated	Russiona Far East	dispersal zone
131	High elevation evergrren	Evergreen	Russiona Far East	dispersal zone
132	Evergreen Needleleaf	Evergreen	GLCC	structural land cover
133	Evergreen Broadleaf	Evergreen	GLCC	structural land cover
134	Deciduous Needlelef	Deciduous	GLCC	structural land cover
135	Deciduous Broadleaf	Deciduous	GLCC	structural land cover
136	Mixed Forest	Mixed Forest	GLCC	structural land cover
137	Closed Shrubland	Scrub	GLCC	dispersal zone
138	Open Shrubland	Scrub	GLCC	dispersal zone
139	Woody Savannas	Savanna	GLCC	structural land cover
140	Savannas	Savanna	GLCC	structural land cover
141	Grassland	Grassland	GLCC	structural land cover
142	Permanent Wetlands	Wetland	GLCC	dispersal zone
143	Croplands	Agriculture	GLCC	dispersal zone
144	Urban and Built-Up	Urban Settlement	GLCC	dispersal zone
145	Cropland and Natural	Agriculture	GLCC	dispersal zone
146	Snow and Ice	Snow/Ice	GLCC	dispersal zone
147	Barren or Sparsely	Barren	GLCC	dispersal zone
148	Water Bodies	Water	GLCC	dispersal zone
149	Sea/not classified	Water	GLCC 2000	dispersal zone
150	Coniferous forests	Evergreen	GLCC 2000	dispersal zone

Table A 5.1 (*continued*) Survey and Restoration Area Prioritization

Identifier	Original land cover	Major land cover type	Source	Suitability
151	broadleaf, evergreen forest	Evergreen	GLCC 2000	dispersal zone
152	Broadleaf evergreen forest	Evergreen	GLCC 2000	dispersal zone
153	Mixed deciduous forests	Deciduous	GLCC 2000	structural land cover
154	Mangrove forest	Mangrove	GLCC 2000	structural land cover
155	Forest mosaics	Degraded forest	GLCC 2000	structural land cover
156	Evergreen shrubland	Scrub	GLCC 2000	dispersal zone
157	Deciduous shrubland	Scrub	GLCC 2000	dispersal zone
158	Sparse shrub and grassland	Grassland	GLCC 2000	structural land cover
159	Grassland on plains	Grassland	GLCC 2000	structural land cover
160	Mosiac of cropping, etc	Agriculture	GLCC 2000	dispersal zone
161	Mixed cropland	Agriculture	GLCC 2000	dispersal zone
162	Cropland	Agriculture	GLCC 2000	dispersal zone
163	Cropland, irrigated	Agriculture	GLCC 2000	dispersal zone
164	Urban Areas	Urban settlement	GLCC 2000	dispersal zone
165	Water bodies	Water	GLCC 2000	dispersal zone

Table A 5.1 (*continued*) Survey and Restoration Area Prioritization

Appendix 6 Cambodia Tiger Conservation Status Review

Detailed Description of Methods for Land Cover Creation

The attached Cambodia tiger status map is an attempt to characterize current tiger distribution and status in Cambodia and more accurately represent the various types of tiger landscapes as set out in the 2005 Tiger Conservation Landscape (TCL 2.0) review exercise.

Some of the conventions and definitions have been modified slightly to be either more explicit than those provided in the TCL 2.0 document or more appropriate for defining the various management areas in the Cambodian context.

Basic information layers

1. Tiger Occurrence Points and Areas

All records of tigers or tiger sign (see detailed descriptions below) since January 2000 are categorized into one of the following 3 categories:

• ***Provisional records*** Credible reports of tiger or occurrence of tiger sign that do not meet the criteria below.

• ***Confirmed records*** Points where tigers have been documented through one of the following:

– Direct sightings (live or remains found in the wild)

– Camera trap photos

– Track observations by trained field personnel satisfying any of the following conditions: total length > 100 mm; total width > 110 mm; pad width > 70 mm

• ***Breeding sites*** Sites satisfying one of the following conditions:

– Points where juvenile tigers have been directly observed in their wild setting.

– Points where tracks of juvenile tigers occur with tracks of adult tigers moving in the same direction at apparently the same time (i.e. conditions rule out confusion with leopards).

– Areas defined by a 7 km buffer around sets of confirmed records collected in both dry and wet seasons for period of at least 2 consecutive years where no point is more than 7 km distant from any other (could be a buffered single point—as in the case of a single camera trap station or water feature with repeat records).

2. Background Themes

Digital georeferenced data used in the delineation and/or presentation of tiger occurrence patterns.

• ***Potential Tiger Habitat*** Areas that satisfy the following 3 conditions:

1) Natural dryland forest formations or mosaic of forested areas with other natural vegetation formations where closed canopy patches of at least 1 km^2 occur within a maximum distance of 4 km from each other over the landscape; and where

2) Points of available water occur within 10 km of each other; and where

3) Known tiger prey species have been documented at points throughout the landscape separated by no more than 10 km.

• ***Disturbance Areas*** All area within 3 km of village sites or within 1 km of a transportation route (not including remote cart tracks, seasonal dirt roads, or walking trails) and selected RAPPMap impact areas[1]. For mapping purposes, the following classes of disturbance areas are defined (see mapping example below):

– ***Disturbance nodes*** Disturbance areas as modeled by 3 km circular buffers around human settlements.

– ***Disturbance corridors*** Disturbance areas as defined by 1 km buffers of transportation routes not within 2 km of a disturbance node.

• ***Suitable Tiger Habitat*** Areas of potential tiger habitat that do not coincide with disturbance nodes.

Management Categories and Associated Mapping Conventions

The maps include (potentially) all of the categories shown on the TCU review maps plus one additional category—Tiger Dispersal Corridors (Number 1 below):

1) ***Tiger Dispersal Corridor*** Areas of unsuitable habitat less than 4 km long but greater than 2 km wide that link areas of suitable tiger habitat greater than 500 km^2 that show at least provisional evidence of tigers.

2) ***Tiger Conservation Landscapes*** Contiguous areas of suitable tiger habitat greater than 1,000 km^2 in size (or smaller areas of suitable tiger habitat linked by Dispersal Corridors) that have had periodic surveys over the last 5 years and show consistent confirmed evidence of tigers over that period.

3) ***Tiger Restoration Landscapes*** Contiguous areas of suitable tiger habitat greater than 1,000 km^2 in size where an established population of tigers (to the best of our knowledge) occurred historically but where relatively high survey effort over the last 5 years has failed to generate any confirmed records of tigers. Additionally, these areas must be in close enough proximity to a viable source population such that conservation or restoration efforts could realistically lead to tigers repopulating the area (i.e. areas that would require the translocation of tigers are not considered).

4) ***Tiger Survey Landscapes*** Contiguous areas of suitable tiger habitat greater than 1,000 km^2 in size where survey effort has been relatively low over the last 5 years and

[1]The RAPPMap assessment took place in October 2004 and identified areas within Cambodia's protected area system that were under the impact of various human activities (Lacerda et al. 2005). The areas included in here include areas that are being logged or otherwise physically degraded by human activity but not areas identified to be under the impact of hunting as the intensity of hunting activities remains undifferentiated.

where surveys (if any) in the last 5 years have failed to produce repeated confirmed evidence of tigers.

5) ***Small Fragments with Tigers*** Contiguous areas of suitable tiger habitat less than 1,000 km² in size that show confirmed evidence of tigers within the last 5 years.

Additional Assumptions and Clarifications

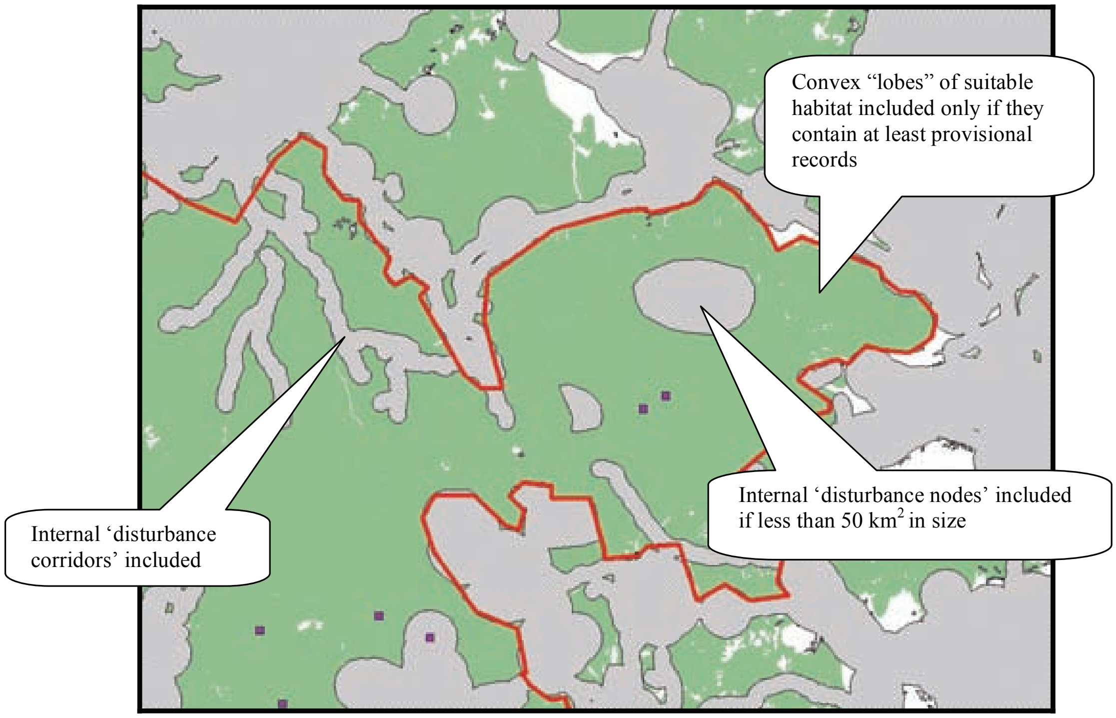

Figure A6.1 Illustration of some mapping conventions used.

The following notes provide clarification of various assumptions and considerations used in the process of delineating Cambodian tiger landscapes:

• Data categories on the map. Although we included criteria for breeding points and tiger restoration landscapes for analysis purposes, please note that no data satisfied these criteria at the time the map was finalized, and therefore they are not represented on the map.

• Survey effort. Although survey efforts at different sites have certainly not been equivalent, combined efforts since January 2000 are deemed to have been sufficient to confidently detect the presence of tiger—if indeed tigers still occur in these areas—in all large blocks (>1,000 km²) of potential habitat with the exception of the 3 tiger survey landscapes identified.

• Landscape versus Fragment. The 1,000 km² threshold for a landscape (as opposed to a fragment) is based on the approximate area necessary to support 12 adult tigers under conservative conditions. The 12 tiger estimate is based on a conservatively large estimated male home range of 150 km^2 (1.5 times Rabinowitz's (1993) estimated Indo-chinese home range size of 100 km^2) and assuming 1 overlapping female range (conservative estimate) for each male range (i.e. 6 males + 6 females = 12 adults).

• Date of Records Used. The TCU review process gives equal weight to tiger records from the last 10 years. This was considered to be too liberal a threshold for all areas of Cambodia based on a pattern of targeted hunting that has accelerated sharply since 1990 (Kenney et al. 1995). Therefore, only records dating from January 2000 have been considered in this assessment.

Notes on Specific Sites (Numbers correspond to numbers on reference map)

1) *Virachey Trans-boundary Area* Consistent records over more than 5 years. Recent reports suggest that tigers are still actively targeted by poachers in the area. The Virachey site links with sites in Laos that may also be important for tiger conservation (e.g. Xe Pian NBCA).

2) *Cambodian Eastern Plains* Although records of tiger have been sparse over the years, recent increases in survey effort have yielded many new records including recent phototraps of large male tigers along the western boundary of Lomphat Wildlife Sanctuary and in the Srepok Wilderness Area of the Mondulkiri Protected Forest. Breeding has been indicated by one record of adult and juvenile walking together in the MPF.

3)*Cardamom Mountains* Tiger records have been dispersed throughout this area with 2 major clusters of records emerging. Although the landscape provides connectivity for the dispersal and interaction of tigers, large blocks of relatively high human impact are almost certainly devoid of tigers.

4) *Phnom Voeene Triangle* This area adjoins what has been designated a tiger conservation landscape and there appears to be potential for tigers to move in and out of the area from Virachey. However, the radically different character of the landscape (i.e. flat, mostly dry forests and significantly greater human traffic in the Voeene area prompted a consensus decision to designate the area as a distinct landscape in need of additional surveys to assess the status of tigers.

5) *Prey Long Wilderness* This is the third largest wilderness area in the country and probably the least thoroughly surveyed for tigers. Although interview surveys in the late 1990s concluded that the area supported the lowest density of tigers in the country (Nowell et al. 1999), there have been consistent anecdotal reports throughout the years and the consensus is that tiger status will remain unclear until additional surveys are carried out.

6) *Western Kulen Promtep* This site shows a number of confirmed tiger records occurring within the last 5 years and therefore satisfies most conditions to qualify as a Tiger Conservation Landscape. However, given that 1) all records are prior to 2003, 2) records

prior to that time have been only sparse in time and space, and 3) there have been only sparse patrols by rangers trained to recognize tiger sign over the last 3 years, the current status of tigers at the site is considered poorly understood and additional surveys are needed to assess their status. The southern lobe of this area where there are several records of tigers was not included as the consensus was that this area has sustained significant conversion to agriculture and other development so as to render it unsuitable habitat for tigers.

7) *Bokor-Kirirom Corridor* Recent aerial surveys indicate that this area still provides reasonable vegetation structure and condition (i.e. degraded forest and bamboo down to approximately 30 meters maximum of the major roadway forming a corridor of at least 3 kilometers in width) to conceivably allow dispersal of tigers. However, land conversion trends and a growing amount of traffic along the road that passes through the area indicate that the corridor's integrity is already in serious doubt. The corridor is thus considered viable but this condition is under immediate threat unless focused conservation efforts are urgently applied.

Participating Organizations

Cat Action Treasury-Cambodia (Hunter Weiler)
Conservation International-Cambodia
FFI Cambodia Programme
Biodiversity and Protected Areas Management Project,
  Ministry of Environment (Peter Cutter)
WCS-Cambodia Program
WildAid-Cambodia Program
WildAid-Thailand Program
WWF-Cambodia Conservation Program

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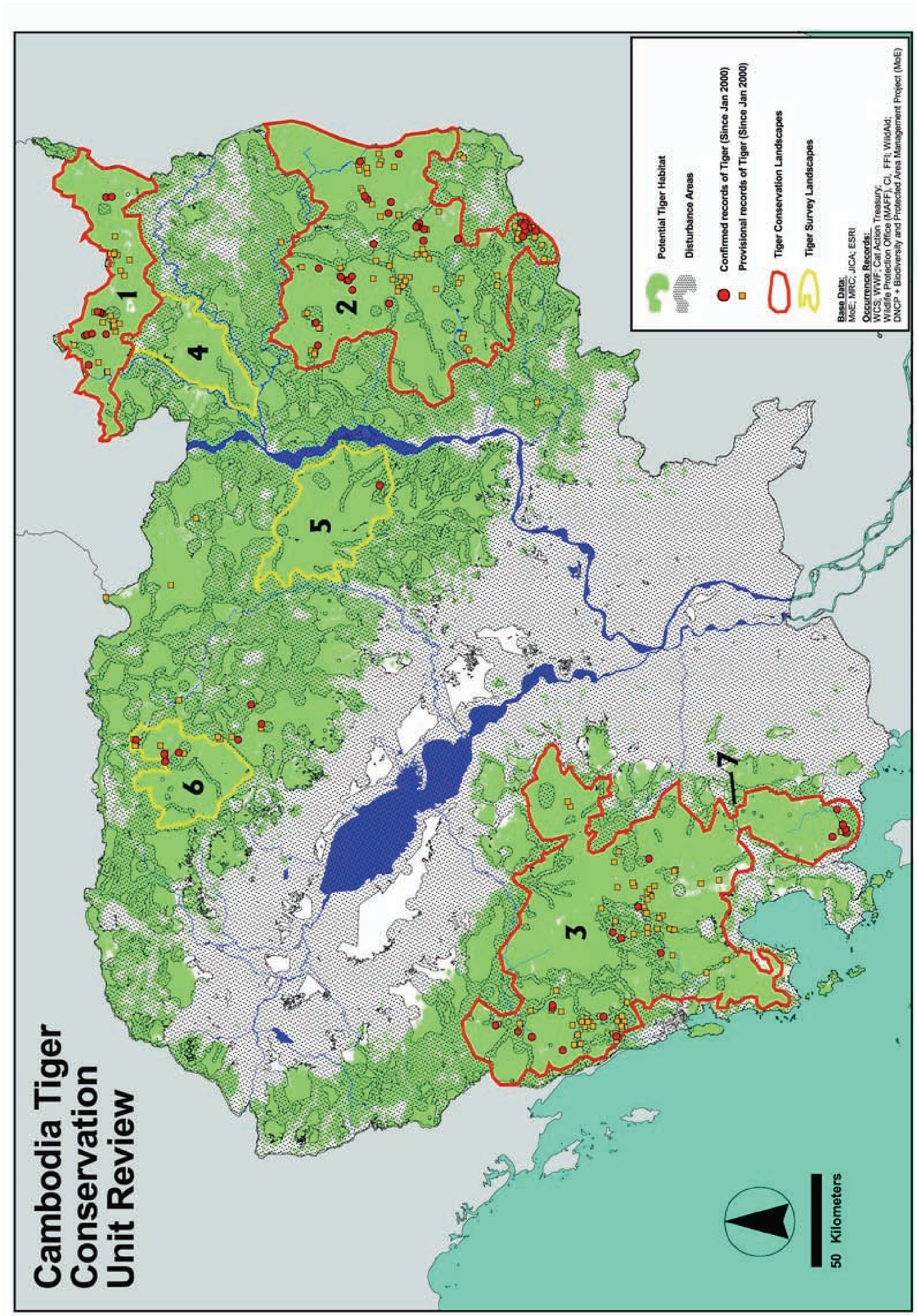
Cambodia Tiger Conservation Unit Review
Potential Tiger Habitat
Disturbance Areas
Confirmed records of Tiger (Since Jan 2000)
Provisional records of Tiger (Since Jan 2000)
Tiger Conservation Landscapes
Tiger Survey Landscapes
Base Data:
MoE; MRC; JICA; ESRI
Occurrence Records:
WCS; WWF; Cat Action Treasury;
Wildlife Protection Office (MAFF); CI; FFI; WildAid;
DNCP + Biodiversity and Protected Area Management Project (MoE)
50 Kilometers
1
2
3
4
5
6
7

GLOSSARY

Classification Categorizes TCLs according to their current condition for supporting tiger populations

Effective Potential Habitat Structural land cover of low human impact

Fragment with Tigers Small areas of structural land cover of low to high human influence that show evidence of tigers. These areas are too small to meet the minimum area requirement to be TCLs, but are important nonetheless for supporting the tigers that live there. Also Tiger Habitat Fragments.

Human Influence Index (HII) A global dataset which scores each 1 km^2 pixel throughout the globe on a human influence scale of 1–72, with 72 reflecting the highest human influence. It is the weighted sum of human population, land use, and power infrastructure datasets (Sanderson et al. 2002).

Potential Habitat Structural land cover in patches ≥ 5 km^2

Prioritization Prioritizes TCLs and Survey and Restoration Landscapes in each major habitat type according to their urgency for future conservation effort and investment

Restoration Landscapes Large areas of structural land cover under low human influence where survey efforts since 1995 have not revealed evidence of tigers.

Structural Land Cover Land cover types that are thought to be suitable for tigers. Also called "suitable land cover."

Survey Landscapes Large areas of structural land cover under low human influence where tiger status is unknown. To our knowledge, these areas have not been surveyed since 1995.

TCU 1.0 First rangewide assessment of tiger habitat, with the analysis done in 1995 and published in 1997. The south and Southeast Asia portion of the tiger's current range was divided into 160 management units called Tiger Conservation Units (TCUs) and these units were prioritized for conservation investment and survey. The work was published as "A Framework for Identifying High Priority Areas and Actions for the Conservation of Tigers in the Wild" (Dinerstein et al. 1997). Also referred to as the Framework Document.

TCL 2.0 This report. Second rangewide assessment of tiger habitat, with work done from 2003 to 2005. Tiger habitat was analyzed across the entire historical tiger range (including China and the Russian Far East) with resultant management landscapes called Tiger Conservation Landscapes (TCLs), Survey Landscapes, Restoration Landscapes, and Fragments with Tigers. TCLs, Survey and Restoration landscapes were further classified as to their current status for supporting tigers and their priority for future investment. Details of the methods and results are written in two complementary documents, one for a technical audience and one for policy-makers. Both are included in this document.

Tiger Conservation Database (TCD) Database of geographically referenced points (tiger point locations) and areas that have been surveyed for tigers, and the results of those surveys. Indicates tiger presence, absence, breeding, and evidence of extirpation; survey methods used to document tigers; data source; and geographical location. Sources include expert submissions, published information, and reports to STF.

Tiger Conservation Landscape (TCL) a block or cluster of blocks of habitat meeting a minimum, habitat-specific size threshold, where tigers have been confirmed to occur in the last 10 years and are not known to have been extirpated.

Tiger Point Location GPS coordinate at which a tiger was identified or a survey took place. Point locations are stored in the Tiger Conservation Database, along with information on evidence of breeding, methods used to document tigers, and source.

TCU Questionnaire Questionnaire distributed to tiger experts in 2004 asking about the status of the 1995 delineated TCUs.

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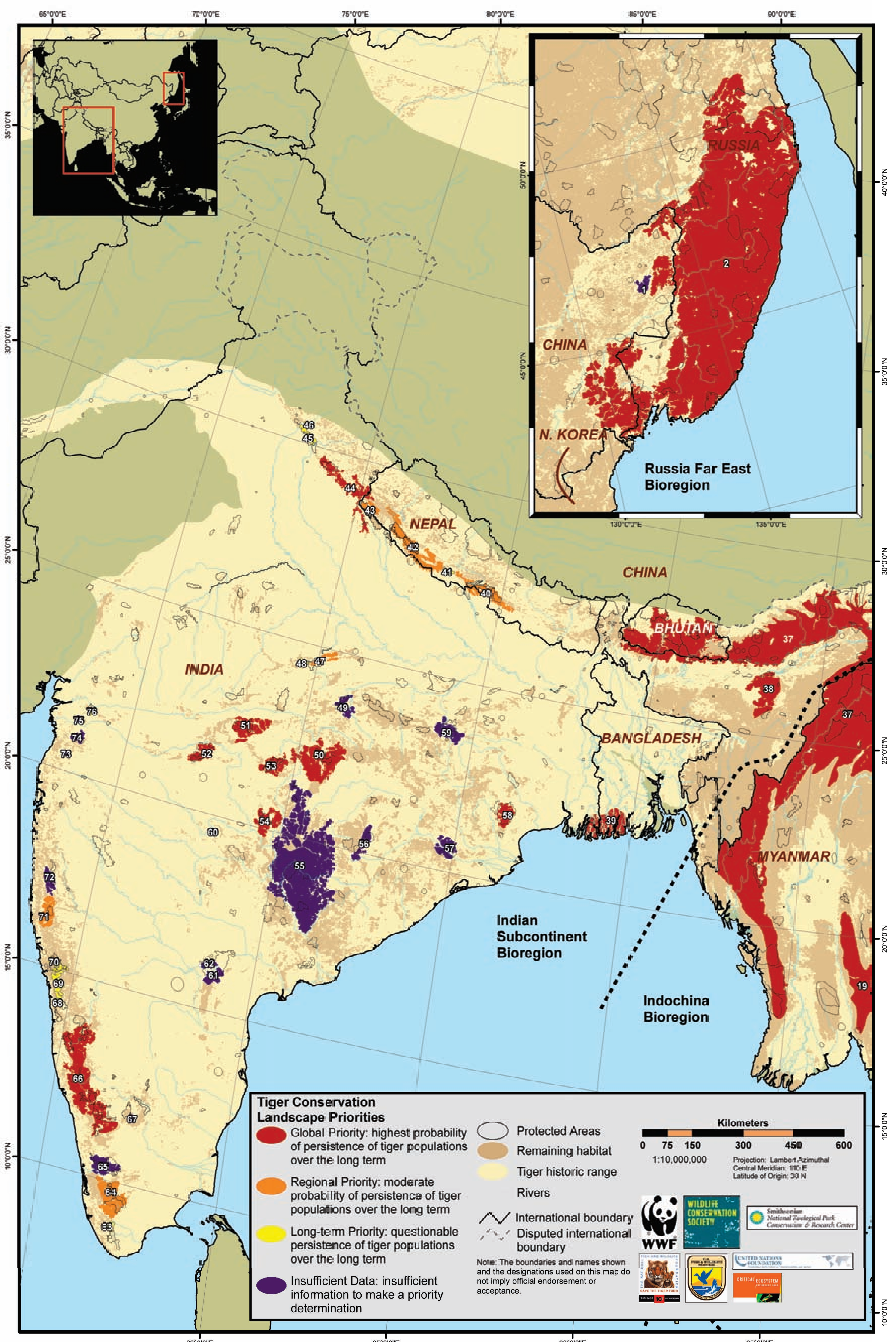

Figure 4.9 Tiger landscape delineation (Indian subcontinent, China and Russia).

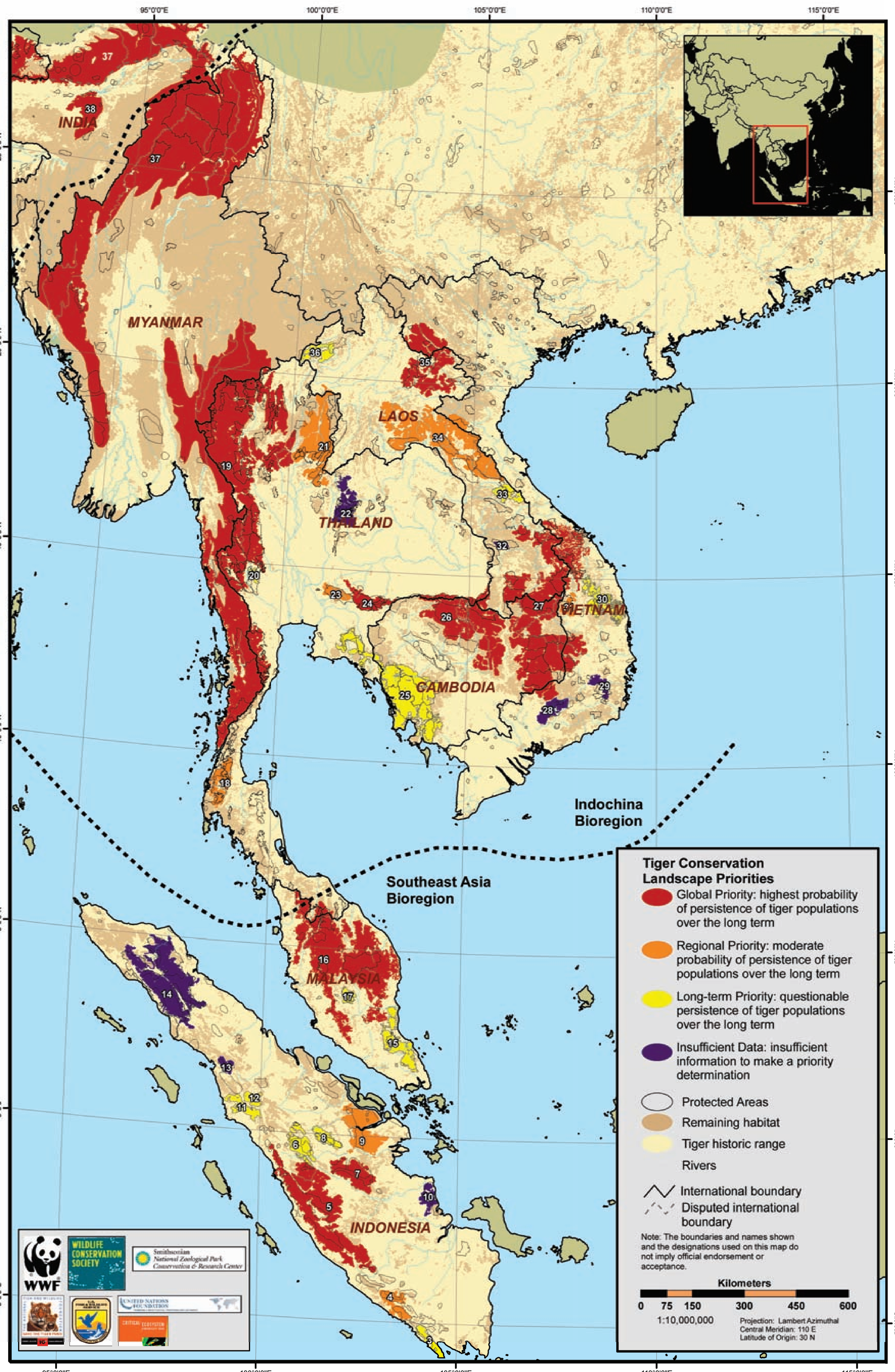

Figure 4.10 Tiger landscape delineation (Mainland Southeast Asia and Sumatra).

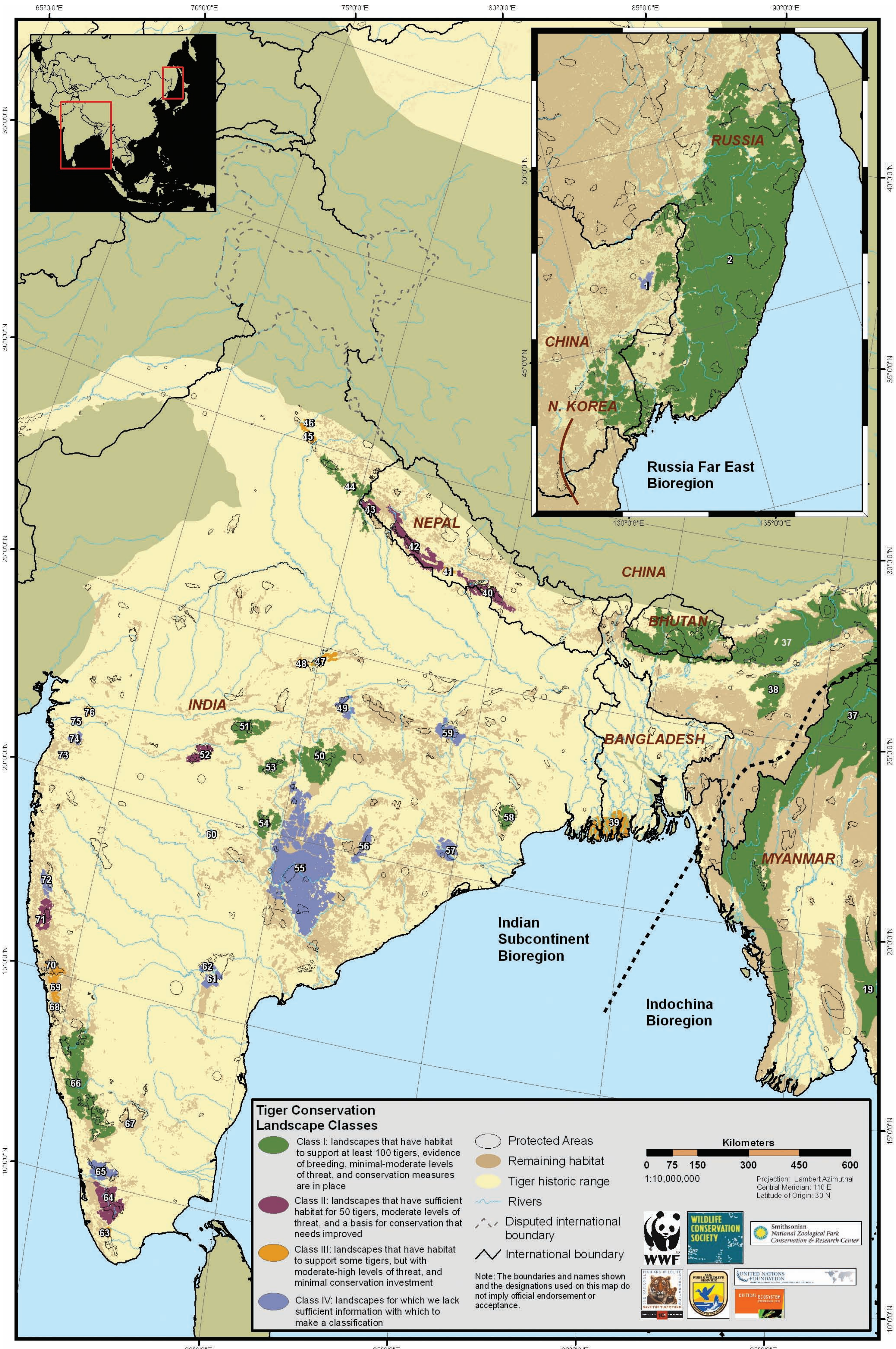

Figure 6.1 Tiger landscape classification (Indian subcontinent, China and Russia).

Figure 6.2 Tiger landscape classification (Mainlaind Southeast Asia and Sumatra).

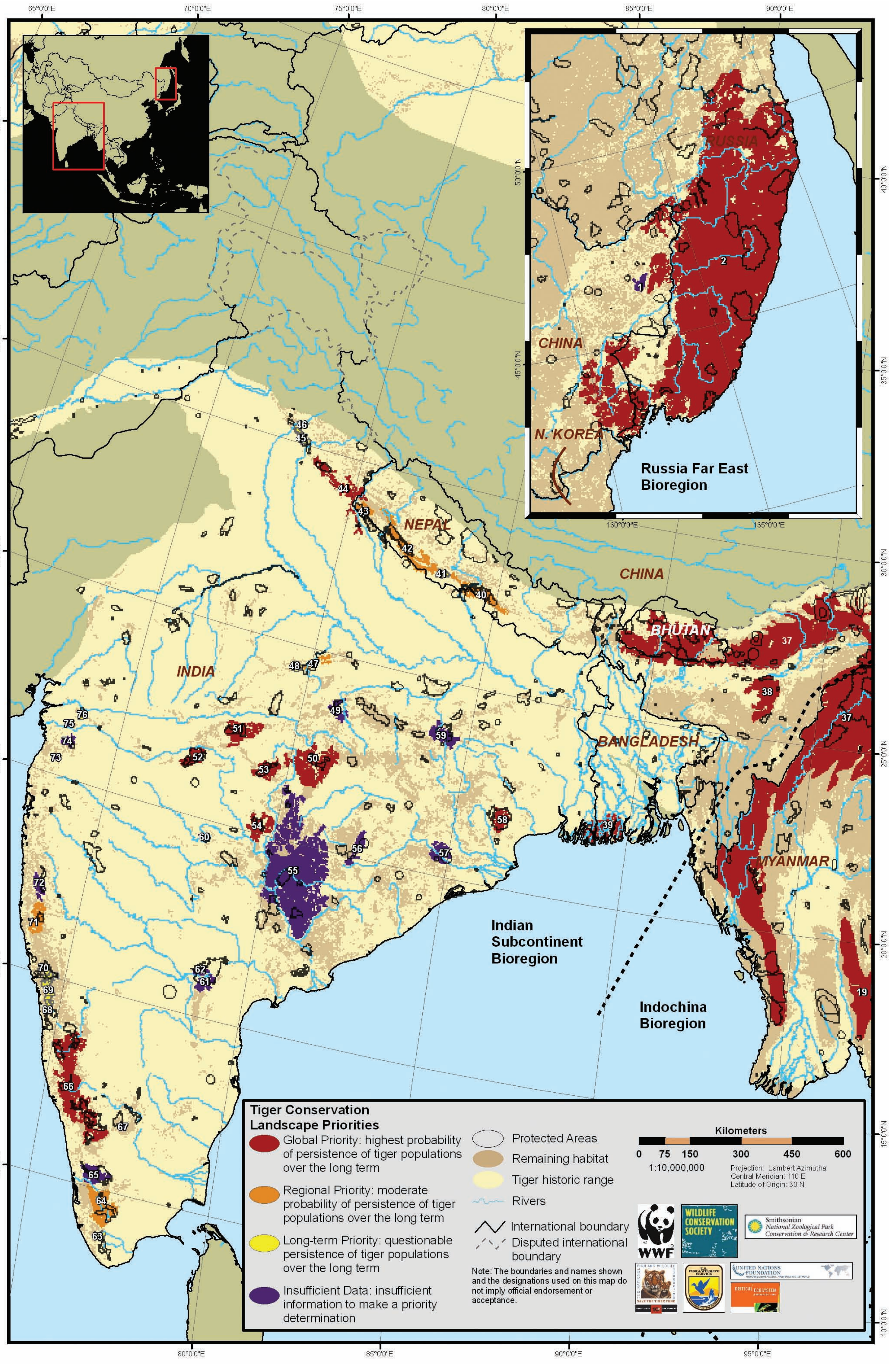

Figure 6.3 Tiger landscape prioritization (Indian subcontinent, China and Russia).

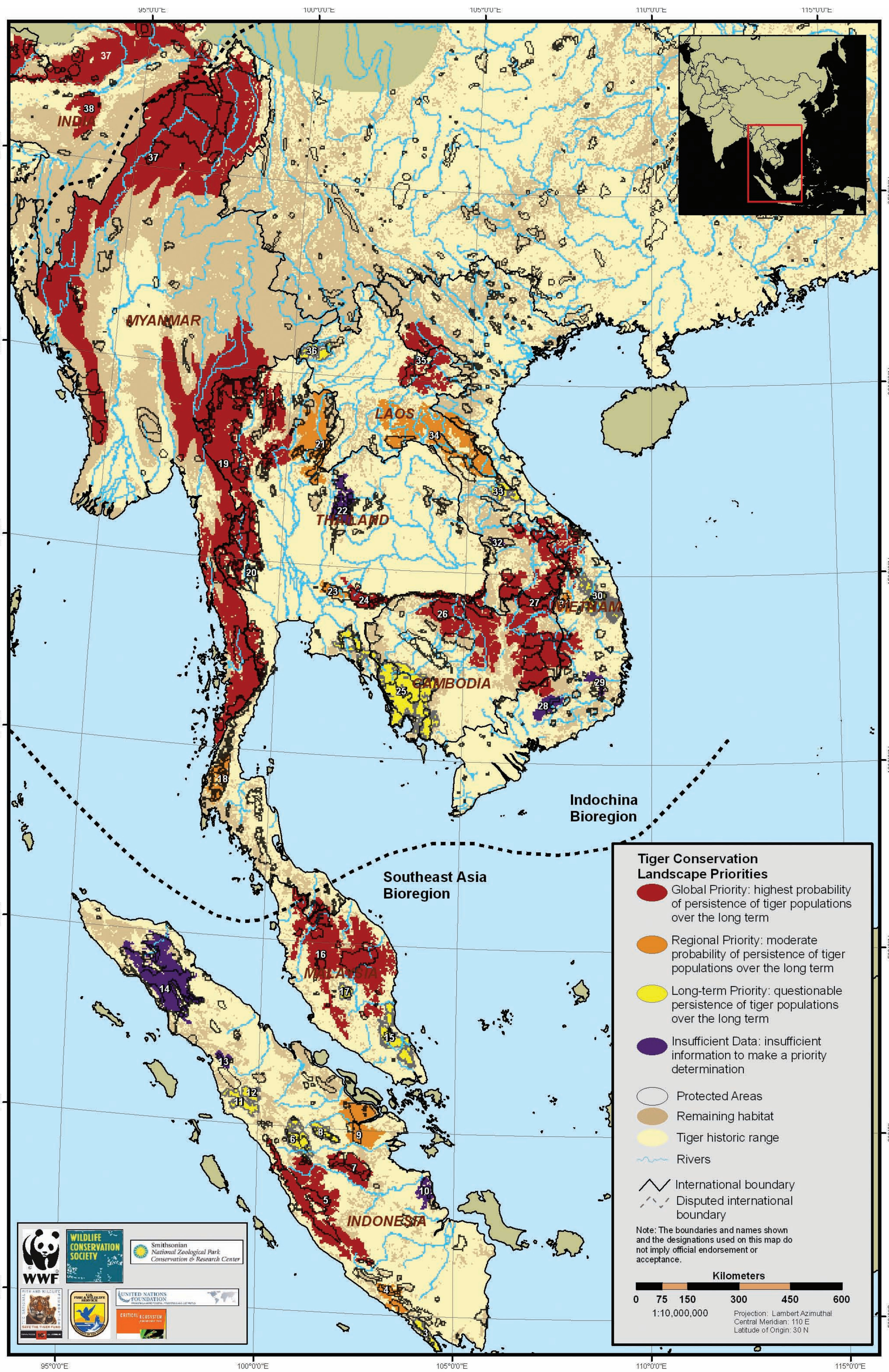

Figure 6.4 Tiger landscape prioritization (Mainland Southeast Asia and Sumatra).