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Tiger Populations and Habitat Monitoring

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Status quo conservation programs are not stemming the loss of wild tigers. We are hemorrhaging tigers to the criminals who kill them for their parts and products; to conflicted economic values that fractionate, degrade, and overwhelm landscapes so they can no longer sustain tigers; and to conservation management systems that are misaligned with today's threats and challenges to meet the tiger's ecological needs at the site or landscape scale. Tigers are at the tipping point in their survival as a wild species; the cause: people. Transparent, scientifically robust monitoring systems to determine how tiger conservation programs are performing is requisite in the platform for a wild tiger stabilization and recovery.

Measurement matters: If you can't measure it, you can't manage it. Human-mediated environmental changes have broadly led to concern about the status of ecological systems and are driving the advance of many ecological monitoring systems worldwide, such as those supporting *The Millennium Development Goals* - Goal 7: Ensure Environmental Sustainability. And those supporting the focal areas selected by the Convention on Biodiversity that include status and trend on the components of biodiversity, sustainable use, threats to biodiversity, ecosystem integrity, ecosystem goods and services, and others.

Recommendations from the Kathmandu Global Tiger Workshop and strategies from the Hua Hin 1st Asian Ministerial Conference on Tiger Conservation implore us to implement scientific systems of estimating and monitoring tigers and their prey to support management actions that increase tiger numbers to twice their present number in the next 12 years, the goal articulated at the Hua Hin ministerial conference.

What controls tiger numbers?

Yogi Berra, the great philosopher and baseball player once said: "If you don't know where you are going, you might wind up someplace else." To double tiger number, you first have to understand what determines the number of tigers at any specific site.

Ultimately, prey numbers and availability do. Tigers are habitat generalists as evidenced by their once-wide distributions in multiple vegetation types through Central, East, and South Asia. Tigers evolved as the specialist predators of large mammals. Tigers are the largest meat-eaters living in Asian wildlands. They kill prey ranging in size from 20 to 100 kg as encountered, but also selectively seek and kill large-bodied ungulate prey -- large deer, wild pigs, and wild cattle -- thereby gaining access to a major percentage of potential prey biomass that is contributed by relatively few individuals. In the absence of human-caused mortality, prey density and distribution, rather than habitat vegetation parameters, explain tiger density. Broadly, however, tiger prey densities vary across

different forest types because the production and availability of food for ungulates varies in different forest types.

A reproducing tiger's home range is defended, and thus, this is its territory. Breeding males defend their territories from other breeding males and these overlap those of several breeding females. Male territory size is dependent on the assertiveness of the resident and adjacent territorial males. Reproducing female tigers exhibit strong intra-sexual territorial behavior and exclude other reproducing females from their territories. A breeding female's territory size tracks available food resources. It must be large enough to support enough prey to feed her and her offspring as they grow and until they disperse at 19 to 28 months of ages. It must be large enough to provide prey to partially feed the resident breeding males. And it must be large enough to supply prey for non-reproducing, transient and temporary immigrants that can compose about 38% of the population. Breeding female territory size increases with decreased prey density so that the number of prey available is similar when territories are small (20 km² in Nepal) or large (500 km² in the Russian Far East).

The amount of tiger prey available in various vegetation types and biomes across the tiger's broad geographical range varies from about 1 to 100 individuals per km². Tigers on average are estimated to remove 10% of all available prey within their territories each year; average kill rate is estimated to be about 50 ungulates per year. Thus, 500 individuals can be considered the prey base needed to provide a tiger with the basic energy it needs for survival. Prey in female territories have been found to exceed by 1.7 times the females' basic energetic need; the prey above the basic amount is required to support growing cubs, and the territorial male and transient tigers that are killing prey from the same base.

Monitoring data have demonstrated that, in response to varying prey densities, tiger densities vary by a factor of 40, from less than 0.5 per 100 km² (tigers one year of age or older) in the temperate forest of the Russian Far East and tropical rain forests to more than 15 per km² in the flood plain savannahs and riverine forests of Nepal and India. Thus, the area it takes to support a viable tiger population in different vegetation types varies accordingly.

A critical problem is that tiger prey populations are depressed both within and outside protected areas through most of the tiger's remaining range. Targets for increasing prey population density that are aligned with potential carrying capacity need to be established as management objectives for each Tiger Conservation Landscape.

What determines tiger population persistence?

In our planning, we need to make distinctions between the state of a particular tiger population and its resilience and potential for long-term persistence. It is essential that meeting the tiger's ecological needs for long-term persistence at the landscape scale are the central concern of tiger conservation efforts. What we have found is that there are

virtually no individual protected areas that are large enough to support viable tiger populations over the long-term.

A population is a group of interbreeding tigers living in a given area. As a rule-of thumb, there is a differential impact of poaching on large and small populations. For example, large populations (>80) can withstand a 10% kill rate. Small populations (<30) crash with a 2% kill rate. A central target then has to be increasing population size both by increasing protected area size and linking protected areas through dispersal corridors.

Populations linked through dispersal are called a meta-population. Source tiger populations are those in which the number of young produced exceeds mortality. Sink populations are those in which mortality exceeds reproductive output; they are not self-sustaining and rely on immigration for persistence. Tiger Conservation Landscapes are areas that can potentially contain a distinct tiger meta-population. They are bounded by a matrix of unsuitable habitat that tigers seem unable to cross. At our current power of resolution, tigers have been reduced to living in 76 such meta-populations.

When the network of protected areas was developed in tiger habitat over the last half century, most of the PAs were nestled in landscape matrices that included suitable tiger dispersal routes to other sites. Today, these same protected areas are islands in a sea of land-uses and infrastructure that stop or greatly restrict tiger dispersal. This has large negative implications for tiger long-term persistence, not only in tiger landscapes but even in protected areas themselves. The conflict with people on PA borders is a major cause of mortality so that border areas represent population sinks. Conservation programs then must seek to maximize protected areas size and mitigate tiger persecution on reserve borders and in buffer zones.

Dispersal plays a critical role in tiger population dynamics because recruitment into a local population is strongly supported by immigration from adjacent populations while many of the population's own offspring emigrate to other areas. Dispersing tigers have been known to travel >100 km through suitable habitat. However tigers are stopped cold by unsuitable habitat, especially open landscapes, unlike leopards and pumas, for example, that are known cross >100 km of highly unsuitable habitat. Ameliorating barriers to dispersal, such as highways, canals, and urbanization, and minimizing human-caused mortality, such as poaching and road kills, are key to promoting successful tiger dispersal and are central to tiger conservation planning.

I paraphrase here from the paper by Chapron et al. (2008), a recent analysis of the impact on tiger population demography of mortality rates associated with poaching:

1. Tigers require large populations to persist, are susceptible to modest increases in mortality, and are less likely than other big cats, such as pumas and leopards, to recover quickly after declines.
2. In contrast to other large felids, tigers breed later and their inter-birth interval is longer, making them less resilient to poaching.

3. While high prey numbers are essential to sustain tiger population, prey recovery efforts will not be sufficient if mortality rates reach 15%. A population with 15% mortality among the breeding females requires 83 breeding females to remain viable. If survivorship of the breeding females is ~ 1.0 , tiger populations can grow at an annual rate of about 20%.
4. Reduction of human-caused mortality, especially of breeding females, is the most essential short-term conservation effort.
5. Because mortality rates are usually unknown and generally stochastic in nature, any management policy that reduces tiger survival rates should be firmly avoided.

One further trait of tigers needs to be highlighted. Breeding male tigers have a propensity for infanticide. When territorial male tigers are killed, the males that replace them as breeders most often kill the offspring of any females that have young. This additional source of mortality can be expected to further dampen any tiger recovery efforts. Excess male turn-over is another negative consequence of tiger poaching.

What will save wild tigers?

The immediate challenges of maintaining wild tigers, even at the local level of protected areas, are daunting. The threats to tigers are pervasive and recurrent. All tiger habitat is embedded in human-dominated landscapes and, conversely, human habitat—villages, farms, roads, mines, plantations, factories—abuts and envelops areas set aside for tigers. Tiger populations nest within human-dominated landscapes of extreme poverty and many landless people. Tiger conservation faces the added challenge of addressing land-tenure issues, local rights, and the legitimate economic aspirations of the rural poor. As a result, conservation management must address very fundamental questions: How can tigers live next to people? How can people live next to tigers? And what management capacity is required to make this possible?

How can tigers live next to people? The good news is that years of experience tell us we can stabilize and recover tigers if we:

- Stop killing tigers. We will probably never be able to stop all poaching but poaching must be reduced at least to a level at which it does not threaten the viability of the population and thus tigers' long-term survival. This requires greatly enhanced law enforcement at the local protected-area level, and at national borders, with regional and international cooperation. The currently huge illegal trade is driven by an increasing demand for tiger parts and products. Any success in reducing the killing will necessarily address the demand side of the supply chain.
- Effectively create (in some TRCs) and maintain (in all TRCs) core tiger breeding areas free from human disturbance, and that meet the tiger's essential ecological needs, including space, cover (forest and grassland), and food (prey such as deer and pigs).

- Connect core areas through forest corridors. The few remaining tiger populations survive mostly in fragmented forest landscapes. Insular reserves, the stronghold of tiger-conservation efforts to date, are rarely large enough to ensure the conservation of ecologically, demographically, and genetically secure tiger populations that are resilient to disturbance events. Tigers must be able to disperse among reserves. Protecting reserves and forming natural corridors has the additional benefit of protecting natural ecosystems that provide humans with the ecological services (e.g., water purification and regulation, regional climate regulation) they need to survive and thrive. Managing landscapes to protect tigers also protects biodiversity and important ecological and evolutionary processes.
- Maintain prey. Even where good tiger habitat remains, prey has been depleted or lost. Prey must be restored and managed in cores and across tiger conservation landscapes.
- Reduce anthropogenic impacts on core areas and corridors, for example by implementing smart green infrastructure development and working with local communities to establish community forests that enhance and support corridor linkages and buffer zones. In short, we have to mainstream tiger conservation into the rural development agenda.

How can people live near tigers? There is also experience to guide what must be done to enable people to live next to tigers:

- People who live near tigers will ultimately determine their fate. They must see the species as a living asset if they are to allow its continual coexistence. But the cost of living in close proximity to tigers means that they will need economic and quality-of-life incentives. On a national scale, tigers and the environmental services their habitats provide must be properly valued.
- Harmonize human needs for infrastructure and other development with what tigers need to survive, such as by implementing smart green infrastructure development. Again, mainstream tiger conservation efforts into the rural development agenda.
- Significantly reduce the risks that tigers and their prey pose to the lives and livelihoods of people who live and work in their proximity so that conflict is below tolerable thresholds.
- Even with successful measures to reduce risks, conflict will arise: tigers will kill livestock and sometimes people; prey species will depredate crops. Effective means to swiftly resolve those conflicts, such as compensation or insurance programs, are required.

What management capacity is required to make this possible?

- A cadre of professional leaders, managers, and staff at all levels working on the ground in tiger protected areas, corridors, and local communities, with appropriate skills and adequate tools.
- Institutional arrangements, policies, and practices that support, monitor, and provide high-value incentives for that cadre of professionals to succeed in stabilizing and restoring the tiger populations entrusted to them.
- Networks of collaborators, colleagues, and partners within and among tiger range states, as well as regionally and internationally, through which knowledge is shared. These networks must be developed among protected area professionals, the scientific community, civil society, and governments.
- Government, business, and public support for tiger conservation that translates into adequate funding, effective policies, and engagement in regional and international programs related to tiger conservation. This is often summarized as “political will.”

Each of these factors can be stated as management targets to be monitored for improving conservation effectiveness.

Monitoring for enhanced conservation effectiveness

Statistically robust and transparent monitoring is essential to keep the tiger crisis on the front burner for years to come. Or as Edward Tufte reminds us, “The assessment of change, dynamics, and cause and effect are at the heart of thinking and explanations. To understand is to know what causes provoke what effect by what means, at what rate.”

However, monitoring data gathered with the vague idea that somehow they will prove useful for conservation is an inefficient use of scarce conservation funding, a form of political and intellectual displacement behavior, and/or a deliberate delaying tactic.

Consider four point of entry for monitoring systems that have emerged in practice to enhance conservation effectiveness. These are interdependent:

- Site-level management effectiveness evaluation;
- Law-enforcement monitoring;
- Assessing occupancy of tigers and their principal prey in tiger conservation landscapes;
- Monitoring the trend in tiger numbers or density and their prey in key sources sites.

Monitoring is not a standalone activity. It is an essential component of the larger practice of science-orientated conservation management. Monitoring must focus precisely on the information needed to make management decisions that link internal processes and employee and system performance to the long-term conservation success that we target: double tiger numbers in the next 12 years. Let’s examine each in turn.

Building core competencies and monitoring site-level management effectiveness

The leaders, managers and staff of protected areas are on the front lines of tiger conservation. Effective protected-area management is fundamental to tiger conservation. There are an estimated 342 protected areas in tiger conservation landscapes. However, only 42 were judged to support source population of tigers (>25 breeding females) in a recent analysis conducted by WCS.

In 2005, the Government of India conducted a management assessment review of 28 tiger reserves using the Management Effectiveness Tool developed by the IUCN World Commission on Protected Areas. This led to a determination that a sizable proportion of the tiger reserves were under performing.

The Management Effectiveness Tracking Tool (METT) is a rapid assessment based on a scorecard questionnaire being used by the World Bank, WWF, and GEF as a mandatory tool for areas in which they are involved. The 30-question scorecard is completed as part of a discussion between the project or task manager, the protected area manager, and representative of local stakeholders.

Later in the Forum we will share experiences with and between Tiger Range Countries on their experience in employing management-effectiveness monitoring.

Law enforcement monitoring

If the criminals don't feel the heat, protected-area management will not succeed. Adapting Geoff Kirkwood's most perceptive observation on the size needed for marine reserves to tigers: "Of course if you really want to know the effective size for a tiger reserve, then we have to multiply its area by the probability that a rogue hunter will be caught and punished if he poaches in the reserve. Recent studies indicated that increases in anti-poaching patrols that increase the risk of detection lead to dramatic declines in levels of poaching."

How do we track "applying the heat"? Law-enforcement monitoring includes ranger-based enforcement monitoring managed through a data and spatial management program such as MIST, Management Information System. It also requires strong intelligence support. In short, effective law enforcement requires a transparent and accountable monitoring system with which to evaluate progress and performance and provide guidance in the allocation of human and financial assets.

In my observation, these GIS-based observation systems engage protectors in a whole new way. Over time, their patrolling and observations are mapped and they can see for themselves the fruits of their work. Protection patrols can compare their compiled observations with those of other patrols. They can track their observation of the larger animals in the protected areas over time. They can track the impact of their own

interventions. These tools are a terrific motivation devise as well as an essential management tool.

This is topic for more extensive discussion later in the Forum.

Assessing occupancy of tigers and their principal prey in tiger conservation landscapes

Because tigers are secretive, prefer thick cover, and live at large landscape scales, counting them with confidence is challenging. Regular and statistically reliable estimates of tiger density and distribution are critical if managers are to detect any rapid changes in populations that may be occurring. Measuring the potential of areas in terms of tiger carrying capacity through an assessment of ungulate densities is of central importance in stabilizing and recovering tiger populations.

The science of counting tigers and monitoring the trends in their numbers has evolved rapidly in the last 15 years. There is no longer any debate on the tradeoffs between science-based sampling and expert-based enumeration. There is a sound statistical framework available and it continues to evolve.

Tiger populations have typically been assessed at two spatial scales: individual tiger populations at specific source sites to establish tiger densities with confidence, usually in a protected area, and measurement of tiger habitat occupancy (distribution mapping) over landscapes, regions, and the entire geographic range.

The pioneering work on documenting and measuring changes in tiger occurrence was conducted in India and the Russian Far East. More recently, the metapopulation structure of tiger populations was documented in Nepal and Thailand. In the last decade, statistically reliable habitat occupancy estimations were generated from Bhutan, Bangladesh, Malaysia, and Myanmar. Indonesia is about to publish Sumatran tiger occupancy data for the entire island; to date it is available for only some areas of the island.

Models for estimating tiger area of occupancy have come forward from India, Bangladesh, Indonesia (Sumatra), and Russia, thus covering a wide range of the vegetation types that tiger occupy. These can be aligned for use in other tiger range countries with similar vegetation types.

What has to be discussed in the scientific community to support tiger occupancy estimation is the size of the sampling grid cells that are appropriate for each landscape, because much can be learned from the characterization of cells that no longer support tigers as well as from those that do.

Monitoring the trend in tiger numbers or density and their prey in key sources sites

The sampling-based approach to monitoring has revolutionized wildlife management. The Save The Tiger Fund has supplied governments and individual conservation

organizations with literally thousands of camera traps in the last 15 years to do this work. The ability to identify individual tigers based on their markings has enabled the application of population assessment based on the capture-recapture statistical platform. This has been augmented recently with software that can be used scan photographs and to identify individuals with certainty. Techniques to establish prey densities using distance sampling and/or measuring the accumulations of prey species feces in plots are well established and have or are being used in a number of TRCs including India, Nepal, Bhutan, Bangladesh, Thailand, Malaysia, Indonesia, Lao, and Russia. India has a particularly robust program. There the work at the level of individual protected areas has been augmented by strong support of conservation biologists in individual protected areas by. It has been strenuously argued by conservation NGOs that they could take on this work and free PA staff to spend more time vigorously protecting PA resources.

Individual tigers can be “captured” using DNA analysis of their hair and feces. Hair can be caught in hair traps but hair traps have not yet been perfected for tigers as they have been for bears. The sequence is as follows: locating tiger scats with specially trained dogs and field assistants, preserving them free of contamination, extracting and analyzing the DNA that can be extracted from the edge of a tiger’s scat, and then analyzing these in a capture-recapture framework. Different climates are more conducive to scat preservation; ever-wet forests offer a poor context for scats preservation while winter in the Russian Far East is the best. Not all individuals in the population will be sampled using scat detection. Consequently, simply using scats to count minimum number of individuals is of limited utility. Alternatively, the methodology to use is the capture-recapture platform has been developed. The barrier to using this technology is that it requires specialized genetic labs that some TRCs do not have. DNA analysis usually must be conducted in-country because most TRCs have restrictions on the export of genetic material.

Our challenge in the Forum is to identify the human and financial resources to scale up site based monitoring to include all protected areas with tigers in the TCLs.

Developing a tiger scorecard

An outline of how to bring this together in a transparent accessible form is an important outcome of this Forum. Let’s call it a tiger scorecard. A scorecard would bring together all site-level management effectiveness evaluations, results of law-enforcement monitoring, trends in the occupancy of tigers and their principal prey in tiger conservation landscapes, and trends in tiger numbers or density and their prey in key sources sites, among other potential measures, such as the level of public support, locally and beyond. Essentially, the tiger scorecard is a tool to move our shared vision into an fundable strategy that can be implemented and its success measured.

As outlined above, there are differences in the scale and dimensions to be measured and tracked, e. g tracking progress in achieving T X 2 at the site, landscapes, ecoregions, and across the entire tiger range. We are also need to track the state of affairs and the change in risk to tiger persistence at these scales.

We began work on such a tiger scorecard a decade ago. That has been a process interrupted, which we must now resume, to broaden our tiger conservation conversation to gain societal support -- the political will -- to support the stabilization and recover of wild tiger populations.