Conservation prioritization for the wild tigers in the Bangladesh Sundarbans

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Introduction

Tiger (*Panthera tigris*) is the largest sympatric vertebrate in the felid guild and is facing unprecedented anthropogenic threats in its native wild lands across South and Southeast Asia (Seidensticker, 1997). This charismatic megacarnivore is a globally endangered species despite the concerted international conservation initiatives over the past several decades to safeguard its dwindling population size across its range nations. Due to its sheer magnificence, mischievousness, and awesome power, the tiger magnetized global attention and became a hallmark species for *ex situ* conservation initiatives across the continents. People around the globe often enjoy visiting zoos, which hold tigers, and many zoos have now adopted the tiger as its priority species for promoting *ex situ* wildlife conservation outreach and education programs with particular focus on schoolchildren as the major target group. Sadly, *in situ* wild tiger conservation initiatives remain disproportionately lacking in terms of scientific and socio-political interventions despite the consensus among civil societies and governments in tiger range countries to protect this species and its habitats. The Sundarbans mangrove ecosystem in Bangladesh is one of such habitats that became a global priority for wild tiger conservation in the 21st century. This paper attempts to place conservation priorities for the free-ranging wild Bengal tigers *Panthera tigris tigris* in the context of the Sundarbans by integrating the modern science of wildlife and landscape ecology.
**Sundarbans tiger ecosystem**

Double the size of the state of Delaware (USA), the Sundarbans is the only mangrove ecosystem in the world where ecological and evolutionary processes have allowed large obligate mammals such as the tiger to adapt to various stochastic and deterministic pressures. No other big cats have managed to adapt to the harsh ecosystem like mangroves by the tropical sea. For example, jaguar (*Panthera onca*) occupies the dense tropical forest ecosystem in South America; lions (*P. leo*) and leopards (*P. pardus*) are found in the vast expanse of the savanna-cum-forest ecosystem in Africa and the mountain lion (*Felis concolor*) makes it home in the temperate ecosystem in North America. All these species have adapted to fit into specific niches in order to survive and breed, but none of them developed mangrove-specific adaptation mechanisms. This puts wild tigers into the forefront considering their superb adaptation mechanism and ecological and behavioral resiliency to survive and successfully breed in the Sundarbans mangrove wetland and thus the Sundarbans have become a topical ecological unit for international conservation research and intervention. With an area covering 6,017 km² in Bangladesh (the remaining ~4,000 km² lies in West Bengal state of India), the Sundarbans is one of the largest deltaic ecosystems with mega-biodiversity significance (Chowdhury, 2004). It has been designated as a Ramsar site (Convention on Wetlands of International Importance) for its high ornithological value. UNESCO (United Nations Educational, Social and Cultural Organization) earmarked a portion of this mangrove ecosystem as a World Heritage Site due to its “outstanding universal value to all the people of the world.” The Sundarbans was also entered as a Global 200 Biodiversity Hotspot as a priority conservation area on earth (Sarat, 1999). Tigers remain the central contributing factor for the Sundarbans to receive such high honors of international designations. The World Wildlife Fund (WWF) and Wildlife Conservation Society (WCS), USA declared the Sundarbans a high priority tiger conservation landscape (TCL) where long-term tiger conservation investment is best. The TCL designation gives better hope for the tigers to survive providing any conservation action programs integrate modern wildlife science-based tiger research backed up by WWF-WCS TCL protocols. This paper is a brief attempt to introduce the scientific know-how and the way forward to set out ecologically valid tiger conservation management priorities. The preliminary objective of such a priority must focus on identifying the prime habitats for the tigers in the Sundarbans so that a long-term viable breeding population can be ensured.

**Ecological framework for the tiger conservation**

Scientific studies of tigers under the modern conceptual statistical framework started with American biologist George Schaller in the early 1960s (Schaller, 1967). His pioneering work in Kanha National Park in India was the major breakthrough in the sense that prior to Schaller’s work, much of the knowledge of wild tigers was based on the anecdotal evidence of colonial hunters’ accounts. His seminal publication *The Deer & the Tiger* remains the fundamental backbone for the graduate biologists who wish to venture into tiger ecology research in the tropical belt.

Major advancements of tiger ecology and conservation research followed between 1970 and 1980 under the Smithsonian Tiger Ecology Project in Chitwan National Park in Nepal (Sunquist, 1981; Smith, 1993). During the 1990s, long-term ecological studies were pioneered by Indian biologist Ullas Karanth in Nagarhole National Park in India. Karanth pioneered the camera-trap/capture-recapture modeling method to estimate population density of wild tigers and substantially improved our current knowledge base pertaining to the demographic, behavioral, ecological and allelic parameters of the wild Bengal tigers in the Indian subcontinent (Karanth & Sunquist, 1992, 1995, 2000). Armed with these new scientific knowledge, WWF and WCS (with funding support from the National Fish & Wildlife Foundation’s Save The Tiger Fund, USA) delivered a scientifically authentic blueprint for a wild tiger conservation

(continued on p.17)
action plan in 1997. This groundbreaking *Framework for Identifying High Priority Areas and Actions for the Conservation of Free Ranging Tigers* is the culmination of 50 years of dedicated and laborious scientific studies undertaken by a handful of wildlife scientists devoted to safeguarding the dwindling wild tiger population across its range nations. The framework introduced a new ecosystem-based tiger conservation approach integrating the geographic information systems (GIS) utilities as one of the fundamental conservation tools to delineate the best heterogeneous ecosystems holding the highest probability for the tiger’s long-term survival under the current and future threats.

Another pioneering component of the WWF-WCS framework was the holistic integration of ecological, demographic, behavioral and genetic differences of tigers in a variety of wild areas that best represents the range of ecological conditions in which they live. (Karanth and Nichols, 2002). This modern framework was also a significant breakthrough and departure from the traditional taxonomy-based putative sub-species conservation management approach which fails to recognize that tigers are uniquely defined by their ecological and demographic parameters. The framework’s principles and applications were based on sound science of wildlife biology and landscape ecology; the disciplines in which satellite imagery, remote sensing and GIS are fundamental components and hence, made a significant contribution to the formulation of the tiger conservation framework. The framework identified seven high-priority tiger conservation landscapes (TCL) where the chances of long-term conservation are the best. Statistical evidence suggests these TCLs pose the highest probability for the long-term survival prospects for the breeding tigers, earmarking these habitats as Level I Tiger Conservation Units (TCU) (Wikramanayake, 1998).

**Sundarbans under eco-political context**

The Sundarbans is one of the seven identified high profile TCU s where tigers are expected to find safe breeding grounds. Therefore, tiger conservation action and priority settings in the context of Sundarbans not only need to parallel the WWF-WCS framework, but also must focus on identifying the best breeding habitats with the potential to sustain a long-term source-pool for the tigers. Sadly, much of these new ecological advancements surrounding tiger conservation are not utilized by the Bangladesh Forest Department (FD) which is the central government organization involved in conservation and protection of biodiversity in Bangladesh. Most of the conservation research regarding Sundarbans tiger have been published in peer-reviewed scientific journals (Karanth, 2003). One of the fundamental setbacks to spearheading standardized sampling-based tiger surveys is largely rooted in the administrative and bureaucratic mindsets of the FD structure. Despite the optimistic reports presented at international tiger conferences, the truth is that wild tiger numbers in the Sundarbans are declining and so far scientifically standardized tiger population estimates and monitoring programs have not been emphasized. Bangladeshi biologist Monirul Khan pioneered the scientifically valid camera-trap capture/recapture modeling method to estimate the wild tiger numbers in the Bangladesh Sundarbans (Khan, 2007). Khan’s estimation suggests there may be approximately 200 tigers in the Sundarbans, where they which they live in a density of 3.7 per hundred km$^2$. In contrast, research conducted by Forest Department (FD) for the past several decades regularly reported that tiger numbers were increasing and the FD’s recent estimation reflects double the figure of Khan’s estimation. Regardless of the eco-political debate surrounding tiger numbers, it is evident that without the formulation of science-based conservation priority against the backdrop of the WWF framework and Khan’s recent estimation, tigers in the Sundarbans may not survive this century and beyond.

**Ecological know-how and the way forward**

The basis of tiger conservation priority settings in the context of Bangladesh Sundarbans requires the holistic integration of two major elements. Firstly, the keystone-umbrella species concept applied to the tiger needs to be taken into account in priority action and policy framework. The
The keystone or umbrella species concept is often used and applied by conservation biologists as a basis for wildlife conservation and protected area management in large geographical landscapes. In the face of limited funding, knowledge and time for action, conservation efforts often rely on shortcuts for the maintenance of biodiversity. The keystone species concept proposes a way to use species requirements as a basis for conservation planning and the concept has recently received growing attention. A keystone species is defined as a species whose conservation is expected to confer protection to a large number of naturally co-occurring species. This concept has been proposed as a tool for determining the minimum size for the conservation areas, selecting sites to be included in protected area networks, and setting minimum standards for the composition, structure and processes (ecological and evolutionary) of ecosystems (Roberge & Angelstam, 2004). Therefore, the health of the Sundarbans ecosystem in terms of its biological and genetic diversity and the ecological and evolutionary processes significantly depends on conserving a healthy population of breeding tigers. In other words, tigers act as an ecological litmus paper to detect any negative changes of the overall health of Sundarbans ecosystem.

Secondly, the tiger conservation action priorities in the Sundarbans context needs to incorporate a landscape-based conservation approach with the addition of remote sensing and GIS as fundamental technical components. Landscape ecology considers vegetation as a mosaic of patches of vegetation with unique landforms, species composition and disturbance gradients and focuses on parameters such as patch sizes, patch shapes, patch isolation, interspersion (adjacency of various land-uses/land-cover), juxtaposition (relative importance of adjacent patches), fragmentation, patchiness, etc. All these parameters have a direct bearing on the status of biodiversity within the forest ecosystem. The spatial analytical capabilities of GIS allow quantifying all the above parameters with the remote sensing-based vegetation type map (Nichol, 1975). GIS and landscape-based tiger conservation priority settings have direct management implications in the long run. For example, protected areas (commonly known as wildlife sanctuaries) constitute approximately 24% of the total area of the Sundarbans. These wildlife sanctuaries are well protected from any kind of anthropogenic interventions and thus relatively good quality habitats are designated as World Heritage Sites (Chowdhury, 2004). It is likely that these pristine sanctuaries have the potential to hold healthy breeding sub-populations of tigers and may be acting as a demographically robust source pools. Wild tigers that disperse from the source pool to nearby habitat patches known as sinks increase the probability of long-term persistence, particularly pronounced in fragmented ecosystems where the GIS component of landscape ecology plays a crucial role in designing the landscape for managing the source-sink dynamics and the metapopulation structure it forms. The principles of conservation biology dictate that protecting the breeding population as a source pool is absolutely indispensable for maintaining the larger population and at present our knowledge is limited pertaining to the source-sink dynamics and the potential transient corridors for tigers to disperse from source pool to sink, thus putting GIS into the forefront to appraise and design the Sundarbans landscape for ecologically validating any tiger conservation action priorities. This kind of study has already been successfully carried out to mathematically identify a system of potential dispersal corridors and strategic transit refuges for wild tigers by using Landsat 7 ETM (Enhanced Thematic Mapper) and GIS utilities in the Terai Arc Landscape, one of the top priority TCLs along the Himalayan foothills in Nepal (Wikramanayake, et al., 2004). By using the GIS-based model, wildlife biologists are able to make recommendations about off reserve land management to increase dispersal potentials for breeding tigers from the source pool through transit corridors to sinks.

Although the study on Nepal’s tigers is based on 30 years of long term ecological data sets, the potential to integrate landsat imagery and GIS tools to answer fundamental questions such as how the spatial and temporal distributional parameters of the tigers in the Sundarbans relates with the currently designated protected areas and whether there is a need to increase the areas of these wildlife sanctuaries is becoming increasingly important for serious carnivore biologists. At
present, knowledge pertaining to the tiger’s range patterns and the potential dispersal corridors from its breeding source pool to its adjacent reserve forest, also known as buffer zones (sinks), is unknown, but remote sensing and GIS-based field surveys hold enormous potential to cost-effectively answer these ecologically vital questions with better timeliness. Source and sink dynamics for managing wildlife populations is now recognized as an important concept in conservation biology and the correct application of this concept against the backdrop of GIS in wild tiger population management in Bangladesh is necessary for tigers to survive this century and beyond.

In good quality habitat patches the source is not necessarily extinction-prone, but rather generates a healthy reproductive surplus, whereas in the relatively unsuitable habitat patches the sink may go extinct in terms of the absence of periodic immigration from the source habitat (Groom, 2006). Identifying the source-sink has direct implications on wild tiger conservation in the Sundarbans. For example, several studies and theoretical models revealed that a small proportion of the total population may be located in the source habitats but are responsible for managing the entire population of any particular ecosystem. Pulliam (1988) showed that as little as 10% of a metapopulation may be found in source habitats and still be responsible for maintaining the 90% of the population found in sinks. Such relationships hold enormous power for effective and ecologically sound policy and conservation decisions, particularly for iconic and large vertebrate endangered species such as the wild Bengal tigers of the Sundarbans. To place the source-sink idea in a better perspective, and more importantly in the context of the Sundarbans tigers, some elaborations are required. Twenty-four percent of the total area of the Sundarbans is internationally designated as wildlife sanctuaries or critical habitats as mentioned above. Until recently, critical habitats were defined as places where a species was most common. Source habitats, however, are defined by ecological, and more importantly, by demographic characteristics as such habitat-specific fecundity success rate and survivorship and not by the population density of the animal (Groom, 2006). Therefore, source habitats for the...
tigers in Bangladesh Sundarbans could easily and mistakenly be overlooked if conservation actions focus priority on the areas where tigers are most common (e.g., wildlife sanctuaries) rather than where they are most productive. Given the limited financial and logistic resource availabilities in Bangladesh, the keystone-species conservation approach and GIS tools that are backed up by ancillary data (e.g., landsat imagery) can play a vital role in identifying productive breeding source pools. These should be the areas where the research priority should be for preserving the tigers in Sundarbans.

Conclusion

This paper attempts to explain the wildlife science-based tiger conservation pathway that integrates the keystone-umbrella species concept, landscape ecology and geographic information systems as major components to effectively devise wild tiger conservation priorities for the Bangladesh Sundarbans. The Bengal tiger is the national icon of Bangladesh, with high cultural, aesthetic and spiritual value even for people with little or no interest in biodiversity conservation. With an improved government institutional framework, the tigers of Bangladesh have recently entered into the statistically rigorous and conceptually unified sampling-based conservation regime. There is hope that the Bangladesh government will positively react to this scientific advancement pertaining to the tigers of the Sundarbans.

References


