Sumatran Tiger Report:
Population & Habitat Viability Analysis

Padang, West Sumatra, 1992

SUMATRAN TIGER POPULATION AND HABITAT VIABILITY ANALYSIS REPORT

OF THE CAPTIVE BREEDING SPECIALIST GROUP OF THE SPECIES SURVIVAL COMMISSION OF IUCN -- THE WORLD CONSERVATION UNION

25 MARCH 1994

Editors:

Ronald L. Tilson
Minnesota Zoo, Apple Valley, MN, USA

Komar Soemarna
Indonesian Forest Protection and Nature Conservation, Indonesia

Widodo Ramono
Indonesian Forest Protection and Nature Conservation, Indonesia

Sukianto Lusli
WWF-Kerinci Seblat National Park, Sumatra, Indonesia

Kathy Traylor-Holzer
Minnesota Zoo, Apple Valley, MN, USA

Ulysses S. Seal
IUCN/SSC CBSG, Apple Valley, MN, USA

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Indonesian Forest Protection and Nature Conservation (PHPA)
&
IUCN/SSC Captive Breeding Specialist Group

A contribution of the IUCN/SSC Captive Breeding Specialist Group, and the Indonesian Forest Protection and Nature Conservation (PHPA).

Cover Photo: Wild Sumatran Tiger, provided by Mike Griffiths.

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SUMATRAN TIGER POPULATION AND HABITAT VIABILITY ANALYSIS WORKSHOP

PADANG, WEST SUMATRA, INDONESIA
22 - 26 NOVEMBER 1992

COLLABORATING ORGANIZATIONS:

INDONESIAN FOREST PROTECTION AND NATURE CONSERVATION (PHPA)

AMERICAN ZOOS AND AQUARIUMS ASSOCIATION (AZA)
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Ueno Zoological Gardens
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Wildwood Park Zoo

4 March 1994

SUMATRAN TIGER
POPULATION & HABITAT VIABILITY ANALYSIS REPORT

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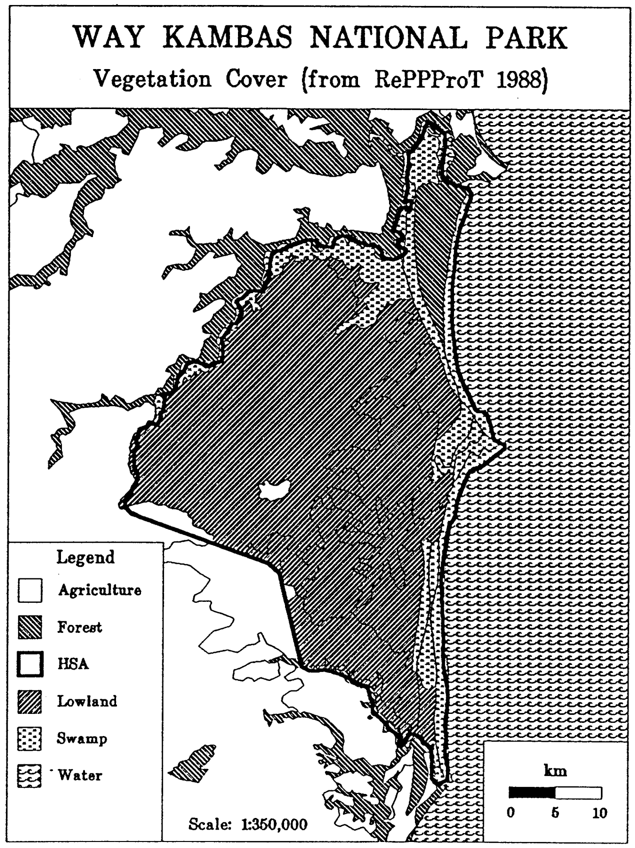

GIS vegetation analysis of Way Kambas National Park, south Sumatra.

SECTION 1

SUMATRAN TIGER PHVA WORKSHOP

Executive Summary

SUMATRAN TIGER
POPULATION & HABITAT VIABILITY ANALYSIS

The first Population and Habitat Viability Analysis (PHVA) Workshop for Sumatran tigers (*Panthera tigris sumatrae*) was held 22-26 November 1992 in Padang, West Sumatra, Indonesia. For the past decade tiger populations in Sumatra have been set between 600 to 1,000 animals, and these estimates were guesses at best. In an effort to more systematically evaluate the distribution, status, threats and viability of Sumatra's remaining wild tigers, IUCN/SSC CBSG and the AZA Tiger Species Survival Plan (SSP) were invited by the Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA) to help coordinate such a workshop. PHVA workshops use computer models (called Vortex) to simulate the deterministic and stochastic, or random, processes that threaten small populations and to explore what effects various management options may produce on the survival of the population.

Within this century eight recognized subspecies of tiger ranged over most of Asia; three were of Indonesian origin on the islands of Bali, Java and Sumatra. The Bali tiger (*P.t. balica*) went extinct 56 years ago; the Javan form (*P.t. sondaica*) was lost 22 years ago. Now the Sumatran form is close to extinction in the wild. The lesson we must learn from these losses is that the last official report on the Javan tiger suggested it would survive if left alone in its last refuge--the Meru Betiri National Park in eastern Java. It didn't survive. More recently, similar recommendations have been suggested for conserving Sumatran tigers. Experience has shown, however, that traditional conservation management guidelines for large felids like tigers have failed or are failing in Indonesia and elsewhere in most of Asia. Extinction of two Indonesian subspecies, and a third called the Caspian tiger (*P.t. virgata*), is ample documentation [the South China (*P.t. amoyensis*) and Siberian (*P.t. altaica*) tigers are also on the verge of extinction]. We need a new vision to save tigers.

This PHVA Workshop was generously supported by Ralston Purina's Big Cat Survival Fund, administered through the American Zoos and Aquariums Association's (AZA) Conservation Endowment Fund (CEF), and the Directorate General of PHPA. Other contributors included the European Endangered Species Programme (EEP -- London, Arnhem and Chessington Zoos), the World Wildlife Fund for Nature (WWF) -- Indonesia Programme, and the Minnesota Zoo. This workshop would have never occurred without their help. Jansen Manansang (Taman Safari Indonesia) took responsibility for organizing the hotel, and Ramon Janis (PHPA) took care of local arrangements with government officials in Padang, West Sumatra.

The agenda was prepared initially by Bapak Abdul Bari (PHPA), Widodo Ramono (PHPA), Sukianto Lusli (WWF Kerinci-Seblat) and IUCN/SSC CBSG. Bapak Komar Soemarna took over when Bari left for the University of Indonesia. To prepare PHPA staff from the National Parks and protected areas of Sumatra, an overland trip through Sumatra, beginning in Medan in the north and finishing in Bandar Lampung in the south, was scheduled in July 1992. During this eight-day odyssey, covering 1,500 km, PHPA and KSDA Offices in Medan (Gunung Leuser), Bukittinggi, Padang, Sungai Penuh (Kerinci-Seblat), Air Hitam, Bengkulu (Barisan Selatan), Lubuklinggau, Kotabumi, Sukadana (Way Kambas), and Bandar Lampung, were visited before crossing the Sunda Straits by ferry for Java.

The purpose of the trip was to inform everyone of the goals of the upcoming Sumatran Tiger PHVA Workshop, and to leave a set of questions along with computer generated maps of each national park overlaid with 100 km^2 grids, requesting information or verification of Indonesian Forestry land-use categories, major vegetation zones, and relative tiger distribution within each grid. The idea was to gather as much information as possible before the workshop, so that our time together could be spent on analysis and recommendations rather than presentation. For the most part this strategy worked.

In the interim the map-linked database, using Atlas Geographic Information System (GIS) software, was being refined at the Minnesota Zoo. Satellite imagery overlays of vegetation cover of Sumatra (from World Conservation Monitoring Center-WCMC) were matched up with Indonesian land-use and forest status maps (series RePPProT 1988) and Geographical maps (1988 series). This database gave a comprehensive spatial analysis of Sumatra which allowed distinctions such as lowland rainforest from montane forest from mangrove forest, protected forest from non-protected forest, rivers from roads, agriculture from bush, and etc. This technique put the H (for Habitat) into the PHVA acronym, and was considered by workshop participants to be a valuable analytical process and an indispensable training tool.

The workshop had a strong contingent of PHPA staff, including Kepalas, Chief Balais, Sub-Balais, and other park staff from the major protected areas of Sumatra -- Gunung Leuser, Berbak, Kerinci-Seblat, Barisan Selatan, and Way Kambas National Parks -- and the smaller protected areas of Lingga Isaq, Lembah Anai, Bajang Air Tarusan Utara, Kerumutan, Seberida, Bukit Rimbang Baling, Peranap, Siak Kecil, Air Sawan, and Batang Merangin Barat. The process was strengthened by the participation of a diverse group of international tiger specialists: Michael Hutchins & Robert Wiese, AZA Director and Assistant Director of Conservation & Science; Sarah Christie, EEP Sumatran Tiger Coordinator; David Pepper-Edwards, Australasian Species Management Programme (ASMP) Sumatran Tiger Coordinator; Scott Frazier, Asian Wetlands Bureau; Jet Bakels, Rijksuniversiteit Leiden; David Smith, University of Minnesota; Mike Griffiths, WWF-Gunung Leuser National Park; Ann Byers, Kathy Traylor-Holzer and Thomas Faust, Minnesota Zoo; David Wildt, National Zoo; Leslie Johnston, Omaha Zoo; and Gerald Brady, AZA Sumatran Tiger SSP Coordinator.

The workshop began with an overview of the PHVA process, moved on to GIS and tiger verification reports from PHPA staff living in the protected areas, recognized the role of cultural concepts in shaping human conduct towards tigers, and considered the threats tigers are now experiencing in Sumatra. Most discussions were in Bahasa Indonesia and were conducted in English when necessary. The working groups were led by Bapaks Poniron (Gunung Leuser), Mega (Kerinci-Seblat), Kurnia (Way Kambas), Frazier (Berbak), and Widodo (Barisan Selatan). The working group reports were synthesized by Komar, Widodo and Effendy (PHPA-Bali Barat), and a set of short- and long-term recommendations for Sumatran tiger conservation were generated and approved.

Tiger troubles were apparent. There was news that 1,081 tiger skins or mounts were recently registered with the Indonesian government following an amnesty on illegal products. Unprotected forest on the edge of National Parks was being lost, and forests within two parks are split by major roads, possibly fragmenting resident tiger populations. With this information in hand, viability analyses of discrete tiger populations using Vortex software were generated. The results were discouraging.

The general consensus was that there were probably fewer than 400 tigers living in five major protected areas of Sumatra. Another 100 or fewer tigers outside of the protected areas were probably not going to survive for long. Gunung Leuser National Park is probably the most secure large area for tigers, Berbak National Park probably has the best habitat for tigers but is the least secure, Way Kambas also has good habitat for tigers but is too small, and Kerinci-Seblat, although the largest, is too fragmented and subject to heavy poaching. Removal of tigers, either through poaching or official trapping of problem animals, is the most sensitive variable of wild tiger populations to consider when projecting their long-term viability. At the end of the workshop we all felt that the future for tigers in Sumatra is not good. It is clear that a national conservation strategy that emphasizes immediate action will be necessary if Indonesia is serious about not losing their only remaining tigers -- *Panthera tigris sumatrae*.■

Problem Statement

SUMATRAN TIGER
POPULATION & HABITAT VIABILITY ANALYSIS

The declining status of all tigers, and the Sumatran tiger in particular, is due to habitat loss and fragmentation, resulting in populations too small for long-term survival in the majority of the national parks and game reserves established to protect them. Poaching for medicinal and economic purposes further exacerbates the small, fragmented population dilemma. Other factors contributing to the overall decline in tiger numbers include decreasing prey availability and increasing tiger control as a result of livestock depredation and human-tiger interactions.

In the case of the Sumatran tiger, an estimated 400-650 tigers *[editors' note: estimate of tiger numbers were reduced at PHVA Workshop]* are believed to be living in five mostly disjunct national parks: Gunung Leuser, Kerinci-Seblat, Berbak, Barisan Selatan, and Way Kambas, and smaller protected areas throughout Sumatra. These numbers are estimates only, are not based on quantitative methods, and are thus not considered reliable. There is little or no gene flow among these separate populations, poaching is ongoing but undetermined in scope, and human encroachment continues to erode the edges of the protected areas.

Of the five extant subspecies of *Panthera tigris*, two subspecies, *P.t. sumatrae* (Sumatran tiger) and *P.t. amoyensis* (South China tiger), were recognized as "critical" based on the Mace-Lande criteria at the May 1991 joint meeting of the IUCN/SSC Captive Breeding Specialist Group, IUCN/SSC Cat Specialist Group and AAZPA Felid Taxon Advisory Group. Due to the wide distribution of the species group and differing problems faced by individual populations, a Population and Habitat Viability Analysis (PHVA) was highly recommended for the taxon, with a PHVA workshop for *P.t. sumatrae* as a top priority.

The goals of this workshop are to:

- conduct a metapopulation and habitat viability analysis by utilizing a Geographic Information System (GIS) for all wild populations of Sumatran tigers;
- formulate management strategies for each population with risk assessments to prevent extinction and achieve the objective of maintaining viable, self-sustaining populations within the historic range of this subspecies; and
- prepare a report of the analyses and results of the meeting with recommendations to the Indonesian Directorate General for Forest Protection and Nature Conservation (PHPA), IUCN Cat & Captive Breeding Specialist Groups, and the CBSG Tiger Global Animal Survival Plan (GASP).

The following workshop objectives will be addressed:

- estimate probable populations of tigers in protected areas of Sumatra using GIS-based habitat assessment techniques, the degree of fragmentation of these populations, and their probabilities for long-term survival with no intervention;

- determine numbers of tigers and subpopulations required for various probabilities of survival and preservation of genetic diversity for specified periods of time (i.e., 50, 100, 200 years) given known sizes of protected areas;
- identify reliable field methods for monitoring population status, assessing prey base, habitat structure and evaluating the cultural perspective of tigers in regards to human-tiger interactions;
- explore the role of exchanges among disjunct tiger populations to maintain viable populations; and;
- formulate and evaluate the possible role of captive propagation as a component of the above management options.

The combination of the above objectives form the basis of the national conservation management strategy for Sumatran tigers. This document will be prepared in draft form during the workshop, and will be reviewed and revised by all participants during the workshop to achieve agreement on its content before departure. It will include specific recommendations and priorities for management and research of both captive and wild populations. Once consensus is reached the document will be translated into Bahasa Indonesian for distribution and implementation throughout Indonesia. The results of this workshop will be refined and used as a model for developing PHVAs for remaining extant subspecies elsewhere in Asia.■

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Direktorat Perlindungan Hutan, Jl. Ir. H. Juanda No. 100 Telp. 323972 Bogor.
Direktorat Pelestarian Alam, Jl. Ir. H. Juanda No. 15 Telp. 323067 Fax. 323067 Bogor.
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Direktorat Penyuluhan Konservasi Sumber Daya Alam, Gedung Pusat Kehutanan Jakarta.

Nomor : 1856/VI/PA-5/92. JAKARTA/BOGOR 26 Sept. 1992.
Lampiran :
Perihal : Lokakarya Harimau Sumatra di Padang

Kepada Yth.

1. Sdr. Kepala Taman Nasional Gunung Leuser
2. Sdr. Kepala Taman Nasional Kerinci Seblat
3. Sdr. Kepala Taman Nasional Bukit Barisan Selatan
4. Sdr. Kepala Taman Nasional Way Kambas
5. Sdr. Kepala Sub Balai KSDA Jambi

di -
Sumatera

Sehubungan dengan akan diselenggarakannya Lokakarya Harimau Sumatera di Padang pada tanggal 22 s/d. 29 Nopember 1992, maka dengan ini kami sampaikan beberapa hal sebagai berikut :

1. Penyelenggaran workshop ini akan melibatkan para pakar dari dalam dan luar negeri yang direncanakan akan diikuti peserta sebanyak 55 orang. Workshop ini diharapkan dapat memberi input management tentang konservasi jenis Harimau Sumatera dimasa depan.

2. Informasi detail tentang distribusi Harimau Sumatera pada wilayah Saudara sangat bermanfaat sebagai bahan pendukung workshop ini, untuk itu Saudara Sukianto Lusli (WWF Kerinci Seblat and Tiger Workshop Co-Coordinator) akan bertugas mengumpulkan peta dimaksud dari Saudara. Peta tersebut harus memuat informasi lengkap berupa (a) penggunaan lahan (TGHK) dan areal penutupan lahan hutan, (b) kondisi tegakan hutan, (c) kehadiran Harimau Sumatera, (d) jenis-jenis satwa yang merupakan mangsa Harimau.

3. Guna menyeragamkan informasi yang akan dimuat di peta tersebut diminta kesediaan Saudara agar dapat mencantumkan informasi-informasi di atas disertai dengan indikator masing-masing informasi tersebut disetiap grid peta dimaksud. Disarankan agar dicantumkan lengkap data peta diantaranya tahun dibuat, skala, dan versi peta dan sebagainya.

Setelah Saudara menyelesaikan peta dimaksud, harap Saudara mengirimkan data tersebut kepada Saudara Sukianto Lusli dengan alamat Taman Nasional Kerinci Seblat Jl. Bukit Lebah Daun Sungai Penuh Jambi paling lambat tanggal 20 Oktober 1992 untuk dikompilasi dan diolah menjadi dasar topik dari diskusi.

Demikian disampaikan atas perhatian dan kerjasamanya diucapkan terima kasih.

DEPARTEMEN KEHUTANAN
DIREKTORAT JENDERAL PERLINDUNGAN HUTAN DAN PELESTARIAN ALAM

Direktur Pelestarian Alam

Abdul Bari TS
NIP. 080013096

Tembusan: Kepada Yth.
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2. Para Kepala Balai Konservasi Sumber Daya Alam se Sumatera
3. Para Kepala Sub Balai Konservasi Sumber Daya Alam se Sumatera

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OPENING ADDRESS

Sutisna Wartaputra
Director General of PHPA

It gives me great pleasure to welcome you all to this island of Sumatra in the Indonesian archipelago to participate at this important International Workshop on Sumatran Tigers. Indonesia once had three subspecies of tiger: in Sumatra, Java and Bali. Unfortunately, as a result of competition with man, the Bali tiger and probably the Javan tiger have become extinct. Today only the Sumatra tiger survives. Its long-term survival in Sumatra will, however, depend not only on strict legal protection and preservation of its habitats but more importantly on our ability to minimize tiger depredations on the one hand and to improve the livelihood of the people living near tiger reserves on the other. Without these people's support, our conservation efforts are unlikely to pay any dividend in the long run.

The Sumatran tiger, like the other large predators and a few of the mega-herbivores such as the elephant, is a species where the basis for its conservation in the wild must be in terms of aiming to keep human settlements and wildlife refuges well separated. This is becoming increasingly difficult to achieve, given the demography of the human populations in Indonesia. Prior to about 1900 when agricultural settlement in Sumatra first led to a substantial degree of deforestation, most of the island was covered in primary forest. Presumably up to that time, although its population density will always have been low, the Sumatran tiger was more or less continuously distributed throughout the whole island. Less than a century later, we find that predator has been squeezed out of huge tracts of forested areas. The conversion of primary forest into agricultural holding is a particularly serious cause of conservation problem in Sumatra, and the tiger has been among the species most seriously affected by it. The IUCN *Red Data Book* lists all the extant subspecies of tiger as endangered.

The government of Indonesia, in recognition of the importance of biodiversity in general and the long-term survival of such keystone species as the rhino, tiger and elephant in particular, has made a long-standing commitment to protect as much as possible the country's natural wealth and heritage. Already Indonesia has established more than 400 conservation areas covering 52,000 km^2 of forest land. In Sumatra many of the important conservation areas such as the Gunung Leuser NP, Kerinci-Seblat NP, Barisan-Selatan NP, Way-Kambas NP, and Berbak NP are large enough to maintain viable populations of tigers. The major national parks in Sumatra cover more than 25,000 km^2 of forest, and they protect not only the Sumatran tiger but also vital watersheds as well as thousands of other animal and plant species, many of them rare or endangered.

The tiger is very exacting in its conservation requirements for two other reasons. The need for extensive forest cover with good populations of mammalian herbivore species as its prey is clear. The other factor is the very high commercial value of the pelt (and bones), which despite strict CITES ban, is still traded illegally in the international market by smugglers. Trade in tiger skin and bones is therefore highly profitable, and even given well-organized customs enforcement, it would be inherently extremely difficult to control, let alone eliminate.

Given this background, the overwhelming emphasis in conservation policy must be on maintaining forest cover over large areas uninterrupted by human settlements and roads, where remoteness, difficulty of terrain and density of cover provide natural protection. The second axiom in any conservation policy for the Sumatran tiger, given the greatly reduced distribution, is that even quite small local populations are valuable and should be protected wherever feasible. Outside the large reserves in Sumatra, there are still tigers struggling to survive in forest patches surrounded by a hostile landscape dominated by man. In such small areas, tiger populations are small and fragmented. Small populations are very vulnerable to extinction, brought about by too much inbreeding and genetic drift. One way of avoiding inbreeding in small isolated populations of tigers would be to link such areas with larger, more secure conservation areas through the establishment of forest corridors.

In addition to such *in-situ* conservation measures, a few tigers could be bred in captivity as the management of "problem" tigers -- ones that often attack livestock as well as humans. Such chronic marauding tigers and man-eaters could be captured for breeding in captivity in zoos. However, despite the tremendous success observed in the breeding of tigers in captivity in Western zoos to date, the potential benefits of reintroduction may not compare with the probable strong opposition from local inhabitants and the substantial financial resources which would be required.

In the final analyses, tiger conservation would require international assistance to boost our national efforts. Such assistance should clearly emphasize the provision of training of wildlife personnel, park planners and zookeepers and the sufficient outlays of funds to protect and manage the tiger habitats in Sumatra.

Finally, the crucial factor in the long-term survival of the tiger in Indonesia is the human population. In a country of over 180 million people with a potential to double within the next 30 years, we must never forget the fact that the people's legitimate aspirations to the enhanced standard of living will cause greater pressure on undisturbed forest habitat than sheer growth in human numbers. Unless we have the ability to meet the impoverished farmers living along the periphery of tiger preserves, there may be no tigers or wilderness areas left for us to protect in the year 2020.

On this gloomy note I leave you to deliberate on the prospects for survival of the magnificent predator in Sumatra -- the Sumatran tiger. With the blessing of Allah the Great, I open this workshop officially.■

Workshop Agenda

SUMATRAN TIGER
POPULATION & HABITAT VIABILITY ANALYSIS

Pangeran's Beach Hotel, Padang, West Sumatra
23-26 November 1992

Sunday, 22 November	
	Workshop participants and attendees arrive in Padang.
	Late afternoon registration.
18:00-19:00	Workshop Coordinators meet (after dinner) to finalize agenda.
Monday, 23 November	
09:00-10:30	Workshop convenes.
	Opening comments (Sutisna, Komar, Padang officials, Seal, Tilson, Hutchins)
	Overview of tiger biology and other papers (Tilson, Smith, Bakels, Griffiths)
11:00-12:00	PHVA overview/initial construction of tiger models (Seal, Tilson, Wiese)
13:30-14:30	Presentation of map-linked database (Tilson, Faust, Sukianto)
14:30-17:30	Working groups/Sumatran Protected Areas (Komar, PHPA staff)
	Data verification for protected areas (Komar, PHPA staff, Tilson, Sukianto, Seal)
20:00	Continue working groups
Tuesday, 24 November	
08:30-12:00	Status reports of working groups (Komar, Poniran, Mega, Kurnia, & other Chiefs)
	Overview of global tiger management strategies (Komar, Seal, Smith, Tilson)
13:30-16:30	Working groups: Evaluation of management strategy for each protected area (PHPA staff)
16:30	Monitoring wild tiger populations (Smith, Griffiths)
20:30	Continue working groups & tiger videos
Wednesday, 25 November	
08:30-11:30	Working group reports (PHPA staff)
	Status and management options for problem animals (PHPA staff, Smith, Bakels, Jansen)
	Genetic management of metapopulations (Wiese, Wildt, Johnston)
13:30-17:00	Integration of management strategies (Seal, Tilson)
	Reintroductions, relocation and genetic transfer as management options (Seal, participants)
Thursday, 26 November	
09:00-11:30	Workshop draft recommendations: overall and site-specific (Workshop Coordinators)
13:30	Workshop wrap-up
Friday, 27 November	
07:00-20:00	Travel to Kerinci-Seblat National Park, Sungai Penuh, Sumatra

Workshop Participants

SUMATRAN TIGER
POPULATION & HABITAT VIABILITY ANALYSIS

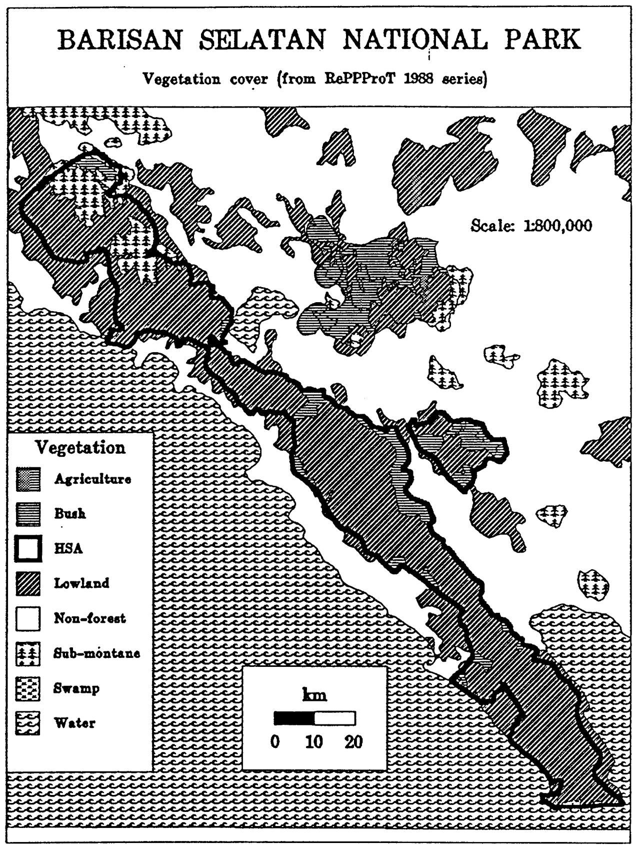
From Indonesia:
Sutisna Wartaputra, DG of PHPA
Komar Soemarna, PHPA
Widodo Ramono, PHPA (Bogor)
Hadi Alikodra, Min. Population & Environment
Herman Haeruman, PHPA (Jakarta)
Effendy Sumardja, PHPA (Bali)
Ramon Janis, PHPA Sub-Balai KSDA
Sukianto Lusli, WWF-TNKS
Fachruddin M. Mangunjaya, WWF-TNKS
Jansen Manansang, TSI
Ligaya Tumbelaka, TSI
Russell Betts, WWF-Indonesia
Michael Griffiths, WWF-TNGL
Scott Frazier, Asian Wetland Bureau
Philip Wells, Sumatran Rhino Survey
Neil Franklin, Sumatran Rhino Survey
Abdul Salam Poroh, Pemda I Aceh
M. Tambunan, Biro BKLH
Kurnia Rauf, PHPA-TNWK
Bintoro, PHPA Sub-Balai Aceh
Susilo Legowo, SBKSDA Bengkulu
Muniful Hamid, PHPA Sub-Balai
Maryono Mahmud, PHPA Sub-Balai
Ikin Z. Muttaqien, PHPA Balai
M. Wazir Nengkeman, Kanwil Bengkulu
Burhanuddin Effendy, PHPA
Marthias Pandoe, Harian Kompas
Muslim Latief, Biro Humas KTR Gubernur
M. Zakir, Anggota Polri
Kayat R. Sutaryo, Dinas Kehutanan
Casmir Rachman, Kanwil Sumbar
Bambang Setyo Budi, Kabid Biphut Bkt Tinggi
Nur Muarif, Kanwil Kehutanan Sumbar
Amirunas SH, Jaksa Penuntut Umum Kejak
S. Poniran, PHPA-TNGL
Gatot Santosa, Media Indonesia
Suhasril Sahir, Suara Pembaruan
Iswan Akhir, KB Bukittinggi
Mega Hariyanto, PHPA-TNKS
Syamsul Kamal, KSDA Musirawas Linggau
Usuluddin, SBKSDA Bengkulu
Asmara Widjaya, Pemda Tk I Bengkulu
Lukman Hakim, BKLH Sekwilda Lampung

From outside of Indonesia:
Ronald Tilson, AZA Tiger SSP Coord./Minn. Zoo
Gerald Brady, AZA Tiger SSP/Potter Park Zoo
Thomas Faust, Minnesota Zoo (GIS)
Ulysses Seal, IUCN/SSC CBSG Chair
David Wildt, AZA Felid TAG Chair/National Zoo
L. David Smith, University of Minnesota
Robert Wiese, AZA Conservation & Science
Jet Bakels, Rijksuniversiteit Leiden
Sarah Christie, EEP Tiger Coord./London Zoo
Doug Richardson, London Zoo
D. Pepper-Edwards, ASMP Tiger Coord/Taronga
Kathy Traylor-Holzer, Minnesota Zoo
Leslie Johnston, Omaha's Henry Doorly Zoo
Ann Byers, Minnesota and National Zoos
Michael Hutchins, AZA Conservation & Science
Keith Highley, Earthtrust
Fachrurrazi Ch. Malley, Earthtrust

SUMATRAN TIGER

POPULATION AND HABITAT

VIABILITY ANALYSIS WORKSHOP



GIS vegetation analysis of Barisan Selatan National Park, south Sumatra.

SECTION 2

DATA ANALYSES AND RECOMMENDATIONS

ESTIMATING HOW MANY TIGERS ARE IN SUMATRA: A BEGINNING

Thomas Faust and Ronald Tilson

INTRODUCTION

Wild tiger are extremely difficult to census because of their secretive nature and near complete avoidance of humans. Even where tigers are censused regularly, as in the tiger reserves of India, their numbers vary from year to year and because the estimates are based primarily upon identification of individual tiger tracks, the reliability of this technique has been suggested to be without scientific basis (Karanth, 1987, 1988, 1993). In Sumatran forests of Indonesia, the census of tigers is compounded by the fact that the national parks are huge, some areas within these parks are practicably inaccessible, and because of low overall prey densities in these habitats, tiger densities are correspondingly low. Remote camera censusing (Griffiths, this report) has provided reasonable estimates of tigers in two areas of Gunung Leuser National Park. This promising technique will need to be greatly expanded in scope before we can use it for ascertaining tiger population estimates throughout Sumatra.

The historical documentation of tigers in Sumatra is meager. In 1978 Borner surveyed Sumatra and estimated the number of tigers to be about 1,000. Since then, Sumatra has undergone much agricultural development and subsequently, pristine tiger habitat has declined. Subsequent surveys of Sumatran tigers by Santiapillai and Widodo (1985, 1987) put the number "not in the thousands but in the hundreds".

Santiapillai and Ramono (1985) first suggested that tiger densities in Sumatra could be as high as 3.7 tigers per 100 km^2. They derived these estimates by extrapolating from tiger densities in optimal habitats of India and Nepal, which are as high as 14 tigers per 100 km^2 (Sankhala, 1979) or as low as 1-2 tigers per 100 km^2 (McDougal, 1977; Smith, 1978; Sunquist, 1981). Santiapillai and Ramono admit that their estimates of tiger distribution were based upon information obtained from local PHPA staff and people living around areas inhabited by tigers, not from direct field observations. With no explanation, they concluded that these estimates were exceptional and that, on average, tiger densities in Sumatra were about 1 tiger per 100 km^2 in mountainous areas and 1-3 per 100 km^2 in optimal lowland habitats (Santiapillai & Ramono, 1987). Using these density estimates, they tentatively suggested that the 26 protected areas in Sumatra could support up to 800 tigers (Ramono and Santiapillai, this report).

At the Sumatran Tiger Population and Habitat Viability Analysis (PHVA) workshop in November 1992, about 35 professional Indonesian forestry and conservation officials assigned to the national parks and protected areas of Sumatra were asked, "How many here in this room have seen a wild tiger?" Four people raised their hands. They were then asked, "How many people have seen tiger tracks?" About one-half of the participants raised their hands. A follow-up question was, "Of those of you who have hands raised, how many have seen tiger tracks ten or more times?" About one-half of the hands went down. Considering that this group comprises the majority of the professional expertise of PHPA from Sumatra, their collective experiences in direct and indirect observations (tiger tracks) strongly suggest that the database was insufficient to make any definitive conclusions regarding tiger population dynamics.

METHODS

With these constraints in mind, we took another approach in estimating tiger distribution and corresponding numbers in Sumatra. A spatial database using Geographic Information System (GIS) was developed for the five major conservation areas of Sumatra. Atlas-GIS was used to map four of the parks: Gunung Leuser, Kerinci Seblat, Berbak and Barisan Selatan; Arc-Info was used to map Way Kambas. Both geological and Land-use/Forest status maps from Indonesia were used to create the spatial database. The layers incorporated into the database were protected areas, vegetation, roads, rivers and settlements.

Indonesian Land-use and Forest Status maps (series RePPProT 1988; scale 1:250,000) were used for protected area boundaries (HSA and HL, see Table 1 for definitions) and vegetation cover. Only vegetation cover within the five major protected areas was digitized from these maps. The main forest types distinguished in the five HSA areas were lowland forest (below 1,000 meters), sub-montane forest (between 1,000-2,000 meters), montane forest (above 2,000 meters), and inland and mangrove swamp. In addition, other vegetation types such as bush and agriculture (along with minor forest types, i.e., calcareous forest) were included in the database.

To estimate vegetation cover outside of the five major protected areas, the World Conservation Monitoring Center (WCMC) provided a digitized coverage of vegetation on Sumatra (series RePPProT 1990; scale 1:2.5 million). WCMC's database only distinguishes between lowland forest, montane forest, inland and mangrove swamp and non-forest. Thus, all areas without forest, such as bush and agriculture, are treated as a non-forest category (Cox and Collins, 1991).

The database created therefore contains a distinction between the information available for vegetation cover inside and outside of the five major protected areas. Outside HSA boundaries all areas without forest are labeled non-forest, while inside HSA boundaries non-forest is divided into bush and agriculture. Roads, towns, and rivers were digitized from geological maps (Geological maps 1988; scale 1:250,000).

Table 1. Categories of protected areas in Indonesia relevant to this report.

HP--Hutan Produksi (Production forest): The removal of timber and other forest products is allowed and regulated to continue on a permanent basis (lowest level of protection).

HL--Hutan Lindung (Protection forest): Forest products can be removed within certain limits.

HSA--Suaka Margasatwa (Game reserve): No activities are permitted that could damage the flora, fauna or landscape; however, permission can be given to allow some traditional use of natural resources, such as hunting, fishing, cutting of timber, and grazing of livestock.

HSA--Cagar Alam (Nature reserve): No activities that could damage the habitat and cause disturbance to wildlife are permitted, except scientific research (upon permission from PHPA).

HSA--Taman Nasional (National park): Level of protection is the same as for the Nature Reserves, except that controlled use for recreation and education is permitted.

To gain input from Indonesian staff of the Directorate General of Forest Protection and Nature Conservation (PHPA) a letter was sent to Mr. Abdul Bari, then the Director of Nature Conservation (PHPA) and Co-Coordinator of the Sumatran Tiger PHVA Workshop, explaining how we were going to go about estimating the distribution of tigers in Sumatra. For purposes of this report this letter is included:

"With this letter we have included a set of five maps, one map for each protected area in Sumatra where tigers are found. Other protected areas may have tigers, but we currently do not have those maps made. The purpose of these maps is to provide a way to estimate the distribution of Sumatran tigers within the five major protected areas of Sumatra: Gunung Leuser, Berbak, Kerinci-Seblat, Barisan Selatan, and Way Kambas. The tiger's distribution will be used to estimate probabilities of long-term survival or mean time to extinction for each population in each protected area. The two smaller protected areas, Berbak and Way Kambas, show little habitat fragmentation. The much larger protected areas are probably highly fragmented. When tiger populations become fragmented, they become smaller and their probability of extinction from environmental, genetic, and demographic stochastic events becomes greater. Thus, long-term conservation strategies to protect Sumatran tigers must consider the protected areas together. If each protected area has a separate conservation strategy independent of the other, the long-term survival of tigers will be uncertain.

We are requesting that each map and a copy of this letter (with the questions) be sent to the Chiefs of each protected area. It is important that this information be gathered quickly, so that we can perform the analyses prior to Tiger PHVA Workshop in Padang, West Sumatra.

Each map has a scale of about 1:250,000 (Berbak and Way Kambas were scaled smaller, the other parks larger). Each map indicates land use patterns (HSA, HL, UNC, etc.) taken from official 1988 RePPProT maps. We have added forest cover or zones (montane, sub-montane, lowland forest, swamps, bush, unclassified, etc.) from WCMC maps (Cambridge, England). We have also indicated major rivers, paved roads, human habitation, and other points of reference (we will continue to add more information up until the November workshop). A latitudinal and longitudinal mark will help with your orientation.

On top of each map we have placed a 10km by 10km grid. This grid will be used to estimate the accuracy of: 1) land use type; 2) forest cover; 3) presence or absence of tigers; and 4) relative density of tiger prey. In some instances the 10km by 10km grid will fall in a transition zone for any or all of the above categories; if so, determine which category is greatest and use that as your answer.

<u>Questions to be Answered</u>
Each protected area map needs to be evaluated by the Chief of that protected area and his staff. Please answer each of the four questions for each 10km by 10km grid (which are numbered).

1) ***Land Use Type:**: Is the land use type indicated for each grid correct? If so, answer yes in the **upper left-hand** corner of each grid. If it is incorrect, answer no in the same spot with the correct land use type (S-HL for example).*

2) ***Forest Cover:** Each grid was developed from satellite imagery that is 20 years old, so the extent of forest cover probably is not current. For each grid, indicate whether the forest cover indicated is correct. If yes, answer yes in the **upper right-hand** corner. If it is incorrect, answer no with the correct forest cover type (e.g., S-BUSH).*

3) ***Presence or Absence of Tigers:** Have tigers, or any sign of tigers (tracks, sounds, scrapings, scats, etc.) been observed in this grid at any time during the last three years? If yes, put a **H** (harimau for tiger) in the **lower right-hand** corner of the grid. If any signs of tiger cubs were also observed, put a **HH** (for mother and cubs) in the **lower right-hand** corner. If tigers have never been observed in this grid, answer no in the same spot.*

4) ***Tiger Prey:** If tiger prey (deer, pig, wild cattle, medium-sized mammals, etc.) are found in this grid, indicate in the **lower left-hand** corner of the grid:*
   - *Many tiger prey present (more than 25 animals)*
   - *Moderate tiger prey present (less than 25 animals)*
   - *Almost no tiger prey present (less than 5 animals)*

   (Editors' note: This category caused the most confusion and was abandoned during the PHVA).

The maps were returned to PHPA in Jakarta and returned to Minnesota for analysis. New maps based upon this information were then prepared for the PHVA workshop.

ANALYSIS OF VEGETATION AND LAND USE PATTERNS

Data were added to the maps at the Sumatran Tiger PHVA Workshop in Padang, Sumatra based on input from the five working groups. The working groups consisted of park officials, field biologists and other individuals with experience working in Sumatra. Each working group was led by the park chief of their respective parks.

SUMATRAN TIGER POPULATION ESTIMATES

The Sumatran Tiger PHVA concentrated on the long-term viability (100 years) of tigers in HSA areas. Other areas, namely HL, were also discussed in terms of tiger numbers but an extensive analysis was not performed on these protected areas, because most of them are scheduled for conversion to agricultural purposes, are extremely small in size and isolated from larger protected areas. This report, as part of the Sumatran tiger PHVA process concentrates on tiger distribution in the five national parks.

In an effort to gain an estimate of tiger numbers in a protected area, we used Griffiths (this report) estimates of tiger home range sizes in Gunung Leuser National Park, who provides the only available data on home range sizes for male Sumatran tigers. He estimated a male tiger has a home range size of about 180 km^2 in elevations from 100-600m. Based on data obtained for prey availability at higher elevations, he estimated a minimum home range size of 274 km^2 at elevations between 600-1,700m and 380 km^2 above 1,700m for males. Female home range sizes were estimated by dividing male home range sizes in half, using data from Nepal; from which he estimated densities for female tigers of 90 km^2 between 100-600m, 137 km^2 between 600-1,700m and 190 km^2 above 1,700m.

We assigned Griffiths' (this report) three tiger densities to available types of vegetation derived from our GIS analysis. For this report, **high tiger density** was placed at 1 tiger per 180 km^2 for a male and 90 km^2 for a female, **medium tiger density** was 1 tiger per 274 km^2 for a male and 137 km^2 for a female and **low tiger density** was placed at 1 tiger per 380 km^2 and 190 km^2. Griffiths' estimates are based on elevation and do not strictly apply to vegetation type, but are close, and help provide a rough estimate of tiger numbers based upon the available data.

Low tiger densities (1 male tiger per 380 km^2, 1 female tiger per 190 km^2) were assigned to montane forest and agricultural. Although agricultural areas may have a higher prey-base (and thus would be good tiger habitat), given poaching and poisoning pressures from humans and the tiger's propensity to avoid humans, it is unlikely that tigers would have an extensive part of their home range covering agricultural lands.

Medium tiger densities (1 male tiger per 274 km^2, 1 female tiger per 137 km^2) were assigned to submontane forest and peat-swamp forest. Submontane forest on the maps roughly corresponds to Griffiths' data (medium tiger densities were from 600 to 1700m, on our maps it is 1,000m to 2,000m). Peat-swamp habitat was assigned to this category, based upon conflicting reports of its suitability as tiger habitat (see section on Berbak National Park, below).

High tiger densities (1 male tiger per 180 km^2, 1 female tiger per 90 km^2) were assumed for lowland forest, swamp (except peat swamp forest), bush and logged forest. Logged forest was included in the high density category because secondary forest is thought to have a higher prey-base than primary forest [(Santiapillai and Ramono, 1987), however, see Wilson and Johns (1982)]. Bush and swamp were included in the high density category based upon the argument that tigers are especially associated with these habitats (Santiapillai and Ramono, 1987).

Tiger numbers for the five national parks were estimated in two ways: 1) using the vegetation cover on the RePPProT (1988) maps stored in the GIS database, and 2) using tiger presence as indicated on the maps by park officials at the PHVA workshop. Kerinci Seblat, Way Kambas, Barisan Selatan and Gunung Leuser all have complete data sets and both methods were used for these parks. Berbak was analyzed using only the vegetation types from the GIS database. The results follow.

RESULTS

GUNUNG LEUSER NATIONAL PARK

There were 177 units in the database for Gunung Leuser, which included adjacent areas. There were 128 units labelled for protection status (88 HSA, 10 HL and 30 NP) and 123 units filled with vegetation cover (49 lowland, 50 submontane, 15 montane, 2 swamp, 2 logged and 5 agriculture). Twenty-eight units were labelled with tiger presence (3 tigers with cubs, 23 tigers and 2 no longer have tigers but they were present in the last three years) and 61 units were labelled for estimated prey-base (38 high, 20 medium and 3 low).

HSA areas: Gunung Leuser had 21 HSA units labelled with tigers (18 tigers, 2 tigers with cubs and 1 tiger within the last five years). The working group only labelled the grids where tigers were known to occur. Much of the park has not been surveyed; thus, there are many more units of suitable tiger habitat for which data are currently unavailable.

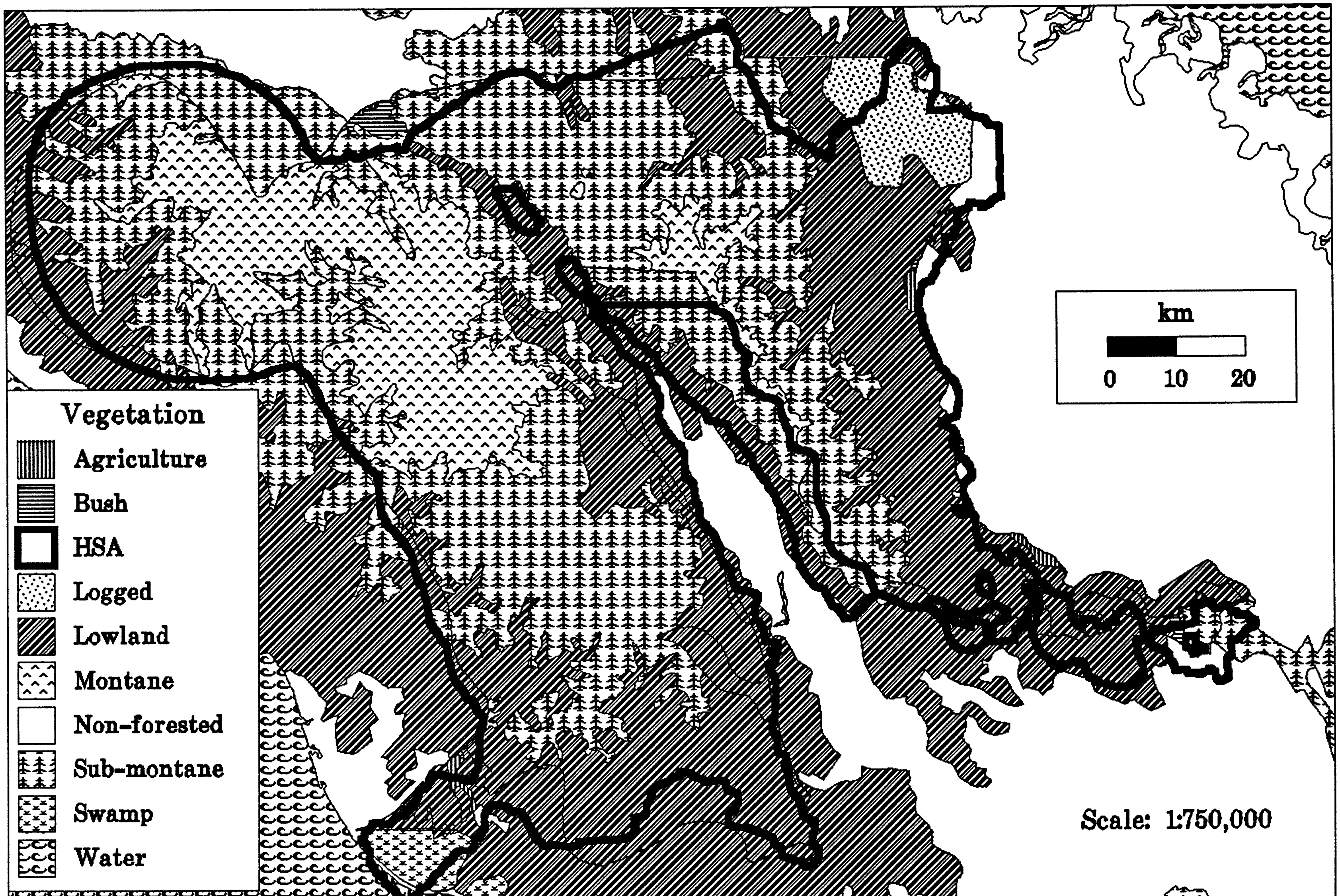
Many of the units for which data were unavailable are of the same kind of vegetation types as units indicated as having tigers present. Tiger presence was indicated by the working group as occurring primarily in lowland and submontane areas. There are many more units of these forest types in the park. Given that tigers are known to utilize submontane and lowland forest, for the purposes of this study, it was assumed that all lowland and submontane areas have tigers present.

<u>Tiger estimates from vegetation in GIS database (data from vegetation analysis):</u> There are 3,749 km^2 of high density habitat (1 tiger per 180 km^2 of lowland, logged, bush and swamp) in Gunung Leuser, for an estimated 20-21 male and 41-42 female tigers. There are 3,644 km^2 of submontane forest in Gunung Leuser, for an estimated 13-14 male and 26-27 female tigers. There are 1,502 km^2 of montane forest and agriculture in Gunung Leuser, for an estimated 3-4 male and 7-8 female tigers. The total population of tigers in Gunung Leuser was thus estimated to be between 110-116; 36-39 male and 74-77 females.

<u>Tiger estimates from HSA areas (from data received at the PHVA workshop):</u> There were 31 units labelled as lowland, swamp and logged. Two units were not labelled and were assigned lowland forest status based on the GIS database. One of the units labelled as swamp was indicated as not having tiger presence and was therefore removed from the analysis. Therefore, there were 30 units of the high density category comprising 3,000 km^2, for an estimated 16-17 male and 33-34 female tigers. There were 41 submontane units in the grid, for an estimated 14-15 male and 29-30 female tigers. There were 15 montane units in the plot, for an estimated 3-4 male and 7-8 female tigers. The total population was thus estimated to be between 102-108 tigers (33-36 male and 69-72 female).

Table 2. Vegetation analysis of Gunung Leuser National Park (8,903 km^2, from RePPProT 1988).

Vegetation type	Total Area (km^2)
Montane	1,461
Sub-montane	3,614
Lowland	3,413
Swamp	24
Bush	45
Agriculture	41
Logged	268



GUNUNG LEUSER NATIONAL PARK
Vegetation cover (from RePPProT 1988)

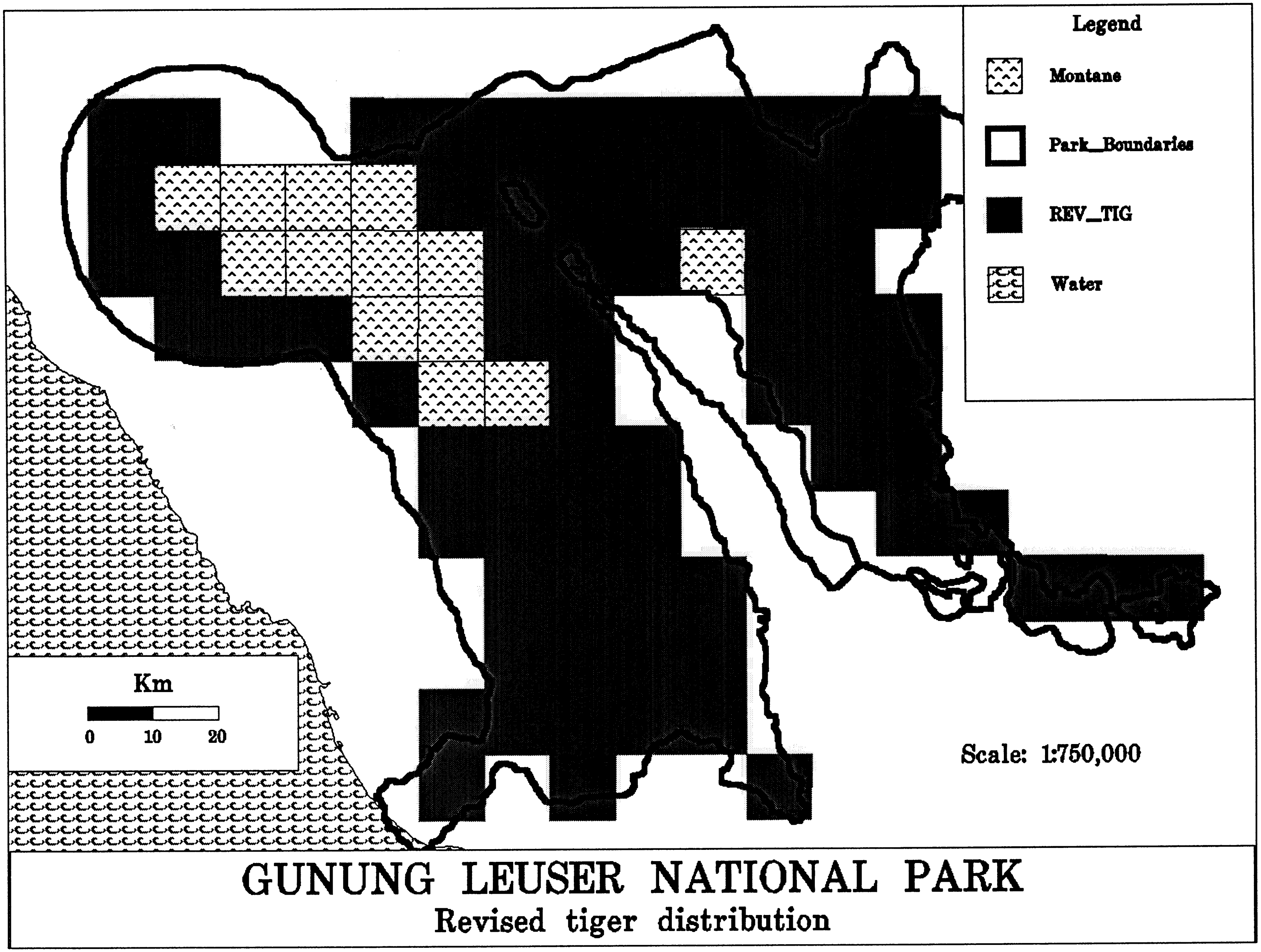

Legend
Montane
Park_Boundaries
REV_TIG
Water
Km
0
10
20
Scale: 1:750,000
GUNUNG LEUSER NATIONAL PARK
Revised tiger distribution

Table 3. Grid of Gunung Leuser National Park.

Land-use	Vegetation	Tigers	Amount of prey H	M	L	NL
HSA (87)	Ll (25)	T (13)	11	0	0	2
		T/C (2)	1	0	0	1
		NL/T (9)	3	6	0	-
		NoL (1)	-	-	-	-
	Sm (41)	T (5)	4	0	0	1
		NL/T (18)	11	7	0	-
		NoL (18)	-	-	-	-
	M (15)	NL/T (6)	0	3	3	-
		NoL (9)	-	-	-	-
	Sw (2)	H (1)	0	0	0	1
		NL/T (1)	1	0	0	-
	Lg (2)	NL/T (2)	2	0	0	-
	NoL (2)	NL/T (2)	1	1	0	-
HL (10)	Ll (6)	T (1)	0	0	0	1
		NL/T (2)	0	2	0	-
		NoL (3)	-	-	-	-
	Sm (4)	NoL (4)	-	-	-	-
NP (28)	Ll (18)	T (4)	2	0	0	2
		T/C (1)	1	0	0	0
		H (1)	0	0	0	1
		NoL (12)	-	-	-	-
	Sm (5)	NL/T (2)	1	1	0	-
		NoL (3)	-	-	-	-
	Ag (5)	NoL (5)	-	-	-	-

Legend: Ll = Lowland forest, Sm = Submontane forest, M = Montane forest, Sw = Swamp, Ag = Agriculture, Lg = Logged; T = Tiger presence, T/C = Tiger with cubs presence, H = Historical presence of tigers, N = No tigers within last five years, NL = Units not marked for amount of prey, NL/T = Grids marked with amount of prey but not tiger presence, NoL = Grids with no labels.

KERINCI SEBLAT NATIONAL PARK

There were 414 units in the Kerinci Seblat database with the following classifications: protection status (108 HSA, 47 HL and 259 non-protected); vegetation (150 lowland, 52 submontane, 2 montane, 9 swamp, 51 bush and 150 agriculture); tiger presence (12 tiger with cubs, 280 tigers, 92 no longer have tigers but they were present in the last three years, 28 never had tigers and 2 tiger presence not indicated); prey-base (144 high, 159 medium and 108 low).

Kerinci Seblat had 94 HSA units that were labelled for tigers; 3 were labelled for tigers with cubs. HSA areas had 3 units labelled as tigers with cubs, whereas non-protected and HL areas had 11 units labelled for the presence of cubs. This suggests that the breeding population is concentrated outside of HSA areas. If only HSA areas provide for the protection of tigers in the future, then the data would indicate that the tiger population in Kerinci Seblat is threatened if the forest cover of the non-protected areas is converted to agriculture.

<u>Tiger estimates from vegetation in GIS database (data from vegetation analysis):</u> There are 5,028 km^2 of lowland and bush in Kerinci Seblat, for an estimated 27-28 male and 55-56 female tigers. There are 4,146 km^2 of submontane forest in the database, for an estimated 15-16 male and 30-31 female tigers. There are 813 km^2 of montane forest and agriculture in Kerinci Seblat, for an estimated 2-3 male and 4-5 female tigers. The total population is between 133-139 tigers, 44-47 males and 89-92 females.

<u>Tiger estimates from HSA areas (from data received at the PHVA workshop)</u>: There were 45 units of lowland and bush labelled with the presence of tigers, for an estimated 25 male and 50 female tigers. There were 30 units of submontane forest labelled for tiger presence, for an estimated 10-11 male and 21-22 female tigers. There were 17 units of agriculture and montane labelled for the presence of tigers, for an estimated population of 4-5 male and 8-9 female tigers. The total population was thus estimated between 118-122 (39-41 males and 79-81 females).

Table 4. Vegetation analysis of Kerinci Seblat National Park (10,018 km^2, from RePPProT 1988).

Vegetation type	Total Area (km^2)
Montane	249
Sub-montane	4,146
Lowland	4,804
Bush	224
Agriculture	566
Water Bodies	10

Table 5. HSA units for Kerinci Seblat National Park.

Land-use	Vegetation	Tigers	Amount of prey H	M	L
HSA (106)	Ll (44)	T (41)	14	16	11
		T/C (1)	1	0	0
		H (1)	0	1	0
		N (1)	0	0	1
	Sm (35)	T (28)	13	8	7
		T/C (2)	2	0	0
		H (4)	1	2	1
		N (1)	0	0	1
	Ag (19)	T (15)	4	7	4
		H (2)	1	0	1
		N (2)	0	1	1
	M (2)	T (2)	2	0	0
	B (3)	T (3)	2	1	0
	Sw (3)	H (3)	0	2	1

Legend: Ll = Lowland forest, Sm = Submontane forest, M = Montane forest, Sw = Swamp, B = Bush, Ag = Agriculture; T = Tiger presence, T/C = Tiger with cubs presence, H = Historical presence of tigers, N = No tigers within last five years.

Table 6. Protected forests units surrounding Kerinci Seblat National Park.

Land-use	Vegetation	Tigers	Amount of prey H	M	L
HL (47)	Ll (26)	T (20)	5	10	5
		H (3)	1	2	0
		N (3)	0	2	1
	Sm (9)	T (4)	2	1	1
		H (5)	2	0	3
	Ag (11)	T (8)	5	0	3
		T/C (1)	1	0	0
		H (1)	0	1	0
		N (1)	0	0	1
	B (1)	T/C (1)	1	0	0

Legend: Ll = Lowland forest, Sm = Submontane forest, B = Bush, Ag = Agriculture; T = Tiger presence, T/C = Tiger with cubs presence, H = Historical presence of tigers, N = No tigers within last five years.

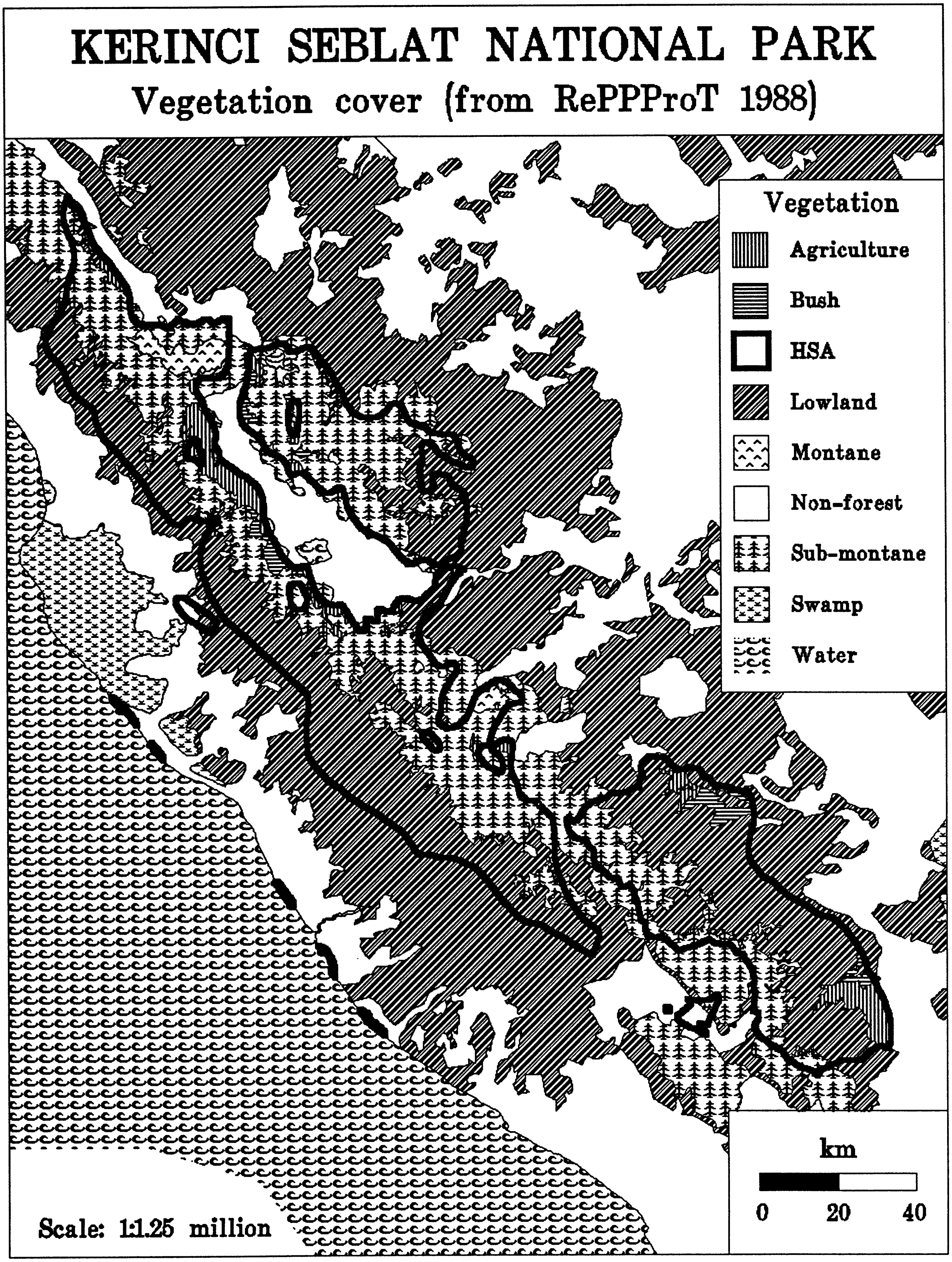
Table 7. Nonprotected units around Kerinci Seblat National Park.

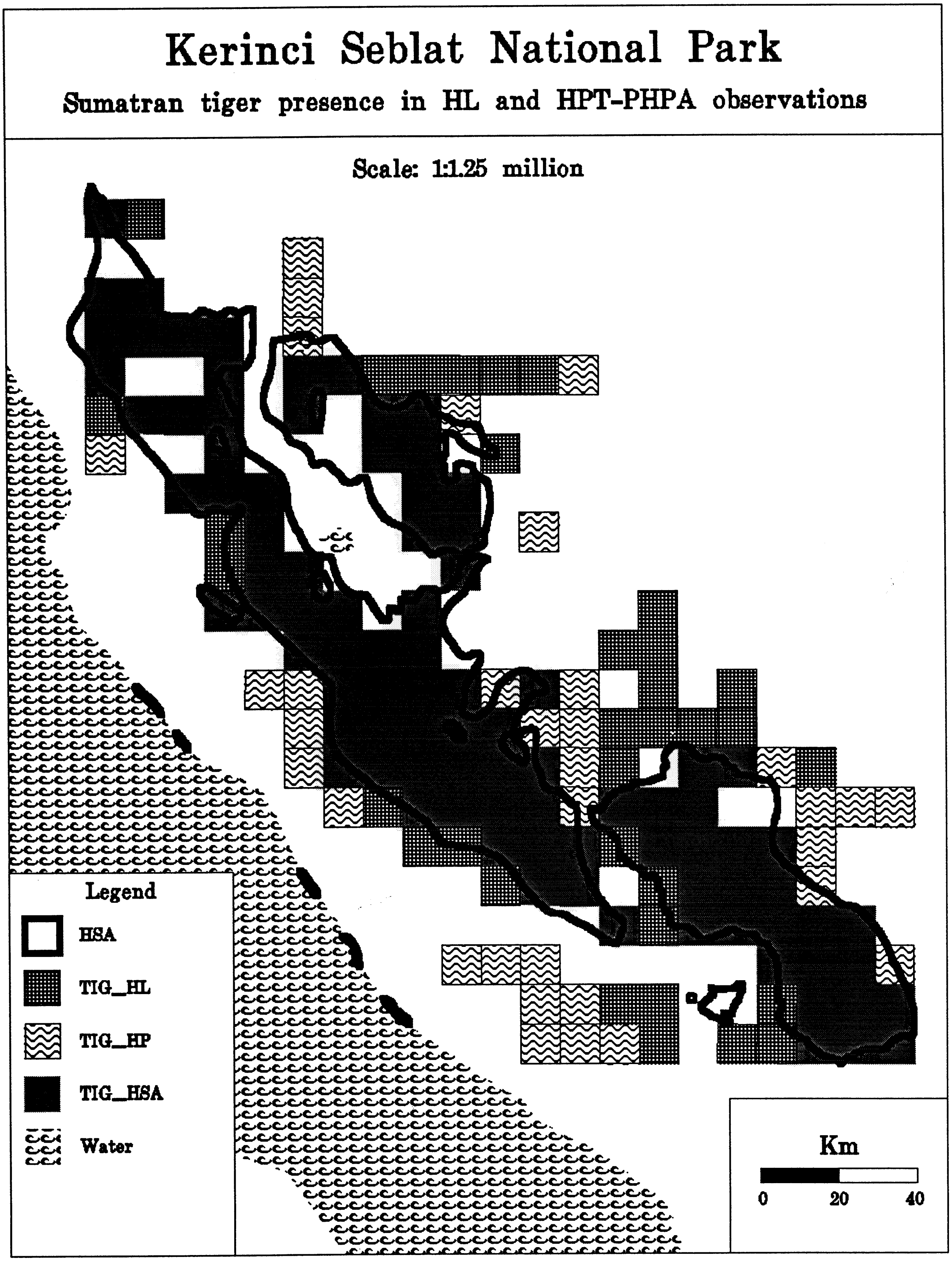
Land-use	Vegetation	Tigers	Amount of prey H	M	L	NL
NP (259)	Ll (80)	T (57)	19	28	10	0
		T/C (3)	3	0	0	0
		H (8)	1	5	2	0
		N (12)	0	3	9	0
	Ag (118)	T (67)	39	19	9	0
		T/C (2)	1	1	0	0
		H (46)	9	20	17	0
		N (1)	0	0	1	0
		No L (2)	-	-	-	-
	Sm (8)	T (5)	1	2	2	0
		T/C (1)	1	0	0	0
		H (2)	0	1	1	0
	Sw (6)	T (4)	0	4	0	0
		H (2)	2	0	0	0
	B (47)	T (24)	8	9	6	1
		T/C (1)	1	0	0	0
		H (15)	2	9	4	0
		N (7)	0	2	5	0

Legend: Ll = Lowland forest, Sm = Submontane forest, Sw = Swamp, B = Bush, Ag = Agriculture; T = Tiger presence, T/C = Tiger with cubs presence, H = Historical presence of tigers, N = No tigers within last five years, NL = Units not marked for amount of prey.

Table 8. Tiger presence surrounding Kerinci Seblat National Park.

Protection Status	Vege-tation	Tigers	Tigers w/ cubs
HL (34)	Ll (20)	20	0
	Sm (4)	4	0
	B (1)	0	1
	Ag (1)	0	1
HPT (33)	Ll (16)	16	0
	Sm (4)	3	1
	B (2)	2	0
	Ag (11)	11	0


KERINCI SEBLAT NATIONAL PARK
Vegetation cover (from RePPProT 1988)
Vegetation
Agriculture
Bush
HSA
Lowland
Montane
Non-forest
Sub-montane
Swamp
Water
km
0
20
40
Scale: 1:1.25 million



Kerinci Seblat National Park
Sumatran tiger presence in HL and HPT-PHPA observations
Scale: 1:1.25 million
Legend
HSA
TIG_HL
TIG_HP
TIG_HSA
Water
Km
0
20
40

Barisan Selatan National Park

There were 299 units in the Barisan Selatan grid database, 59 were labelled with information. The units were labelled for protection status (34 HSA, 4 HL and 21 non-protected), vegetation class (36 lowland, 11 submontane and 12 agriculture), tiger presence (27 tigers, 19 no longer have tigers but they were present in the last three years and 13 never had tigers) and estimated prey-base (31 high, 23 medium, 4 low and 1 not labelled).

There were 34 HSA units in Barisan Selatan; of these 19 had tigers (17 lowland, 1 submontane and 1 agriculture), 12 had tigers within the last three years and 3 never had tigers (*editors' note: tigers may be fragmented into five populations.*

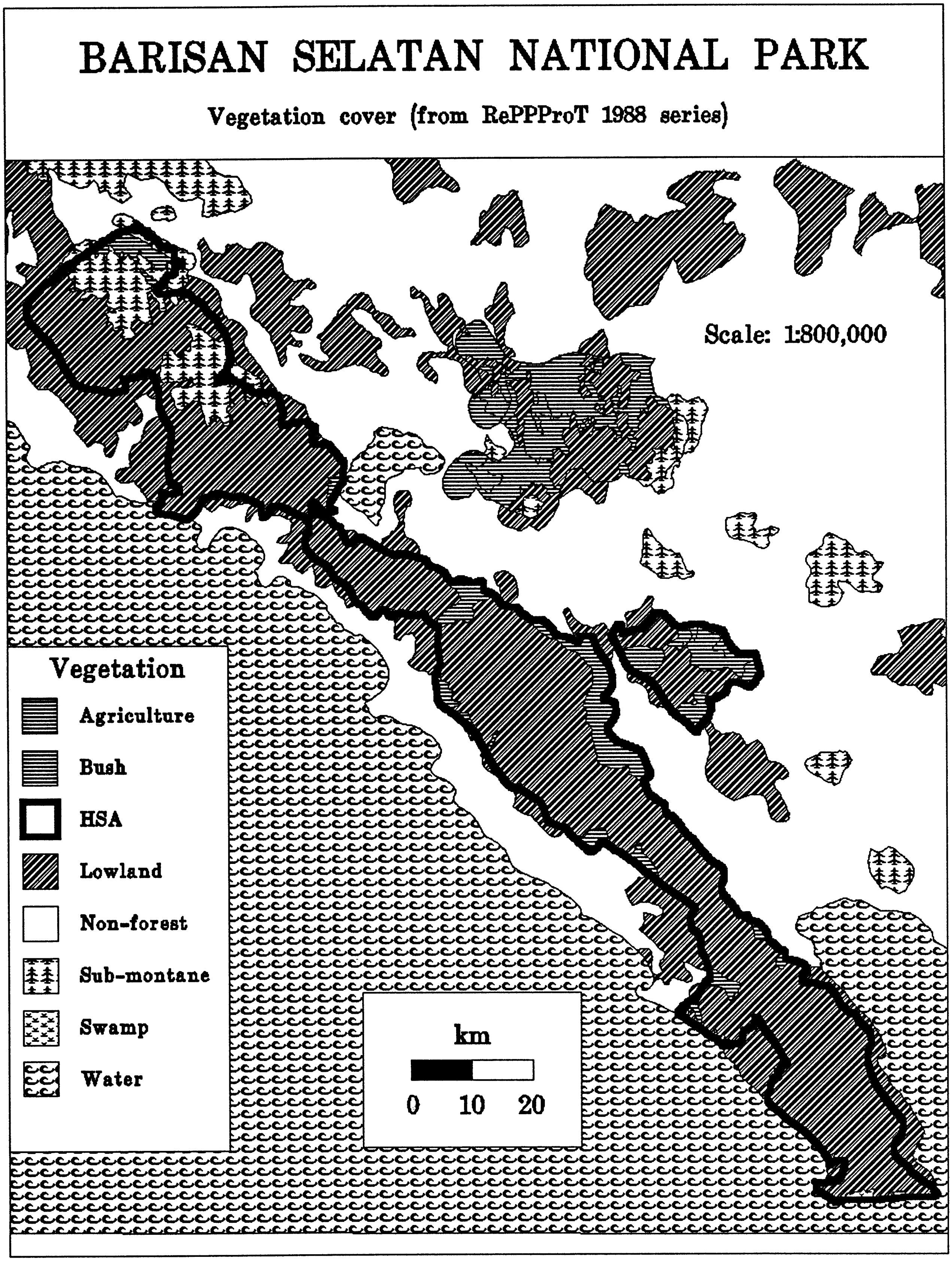
<u>Tiger estimates from vegetation in GIS database (data from vegetation analysis):</u> There are 2,715 km^2 of bush, lowland and swamp forest in Barisan Selatan. This results in an estimate of 15-16 male and 30-31 female tigers. There are 268 km^2 of submontane and 324 km^2 agriculture within park boundaries. This results in estimates of 1-2 male and 3-4 female tigers.

From the GIS vegetation analysis, the male population is estimated to be between 16-18 and the female population between 33-35 tigers, or a total population between 49-53 tigers.

<u>Tiger estimates from HSA areas (from data received at the PHVA workshop):</u> From the tiger distribution received at the PHVA workshop, the tiger population of Barisan Selatan appears to be fragmented into five separate populations. The number of individuals is estimated for each population, from south to north.

The first population has 1,000 km^2 of lowland forest, for an estimated population of 5-6 male and 11-12 female tigers. The second population has 200 km^2 of lowland forest and 100 km^2 of agriculture, for an estimated population of 1-2 male and 2-3 female tigers. The third population has 200 km^2 of lowland and 100 km^2 of submontane forest, for an estimated population of 1-2 male and 2-3 female tigers. The fourth population 4 has 200 km^2 of lowland forest, for an estimated population of 1-2 male and 2-3 female tigers. The fifth population has 100 km^2 lowland forest with an estimated tiger pair.

The total population, using tiger presence from the grid, was estimated to be between 9-13 males and 18-22 females. If the tiger population is fragmented as depicted, there is suitable tiger habitat between these populations and because the distances between the populations are not great, tigers can probably cross these areas. Therefore, the populations are more than likely not genetically isolated.


BARISAN SELATAN NATIONAL PARK
Vegetation cover (from RePPProT 1988 series)
Scale: 1:800,000
Vegetation
Agriculture
Bush
HSA
Lowland
Non-forest
Sub-montane
Swamp
Water
km
0
10
20

Barisan Selatan National Park

Sumatran tiger presence-PHPA observations

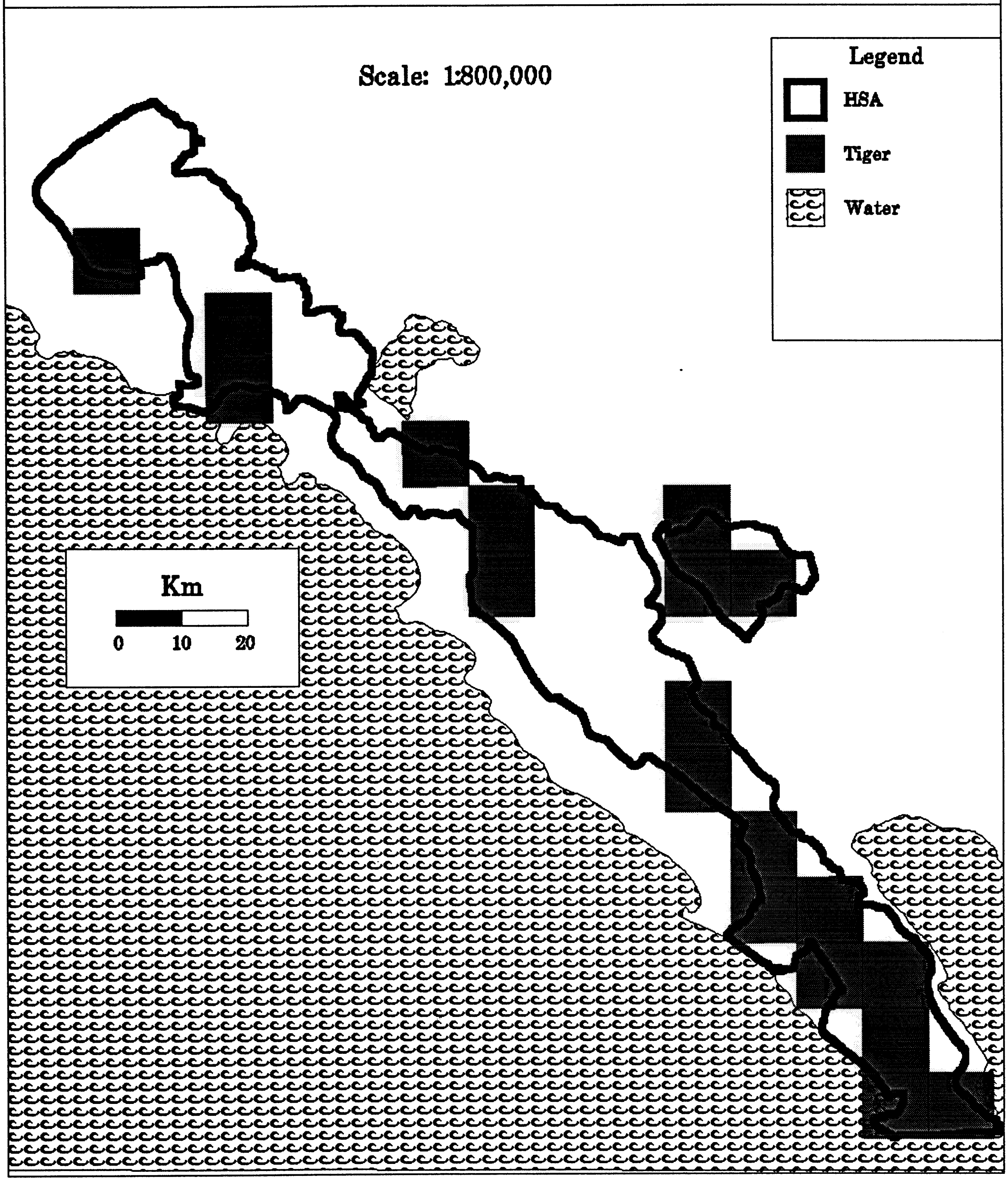


Table 9. Vegetation analysis from Barisan Selatan National Park (3309 km^2, from RePPProT 1988).

Vegetation type	Area (Km^2)
Lowland	2,643
Submontane	268
Swamp	16
Bush	57
Agriculture	324

Table 10. Grid of Barisan Selatan National Park.

Land-use	Vegetation	Tigers	Amount of prey			
			H	M	L	NL
HSA (34)	Ll (25)	T (17)	12	4	0	1
		H (6)	2	4	0	0
		N (2)	1	1	0	0
	Sm (8)	T (1)	1	0	0	0
		H (6)	4	2	0	0
		N (1)	0	1	0	0
	Ag (1)	T (1)	1	0	0	0
HL (4)	Ll (2)	H (2)	2	0	0	0
	Sm (2)	T (1)	1	0	0	0
		N (1)	0	1	0	0
NP (21)	Ll (9)	T (6)	4	2	0	0
		H (2)	2	0	0	0
		N (1)	0	0	1	0
	Sm (1)	H (1)	0	1	0	0
	Ag (11)	T (1)	1	0	0	0
		H (2)	0	2	0	0
		N (8)	0	5	3	0

Legend: Ll = Lowland forest, Sm = Submontane forest, Ag = Agriculture, T = Tiger presence, T/C = Tiger with cubs presence, H = Historical presence of tigers, N = No tigers within last five years, NL = Grids not marked for amount of prey.

WAY KAMBAS NATIONAL PARK

There are a total of 28 units in the Way Kambas database. The units were labelled for protected status (16 HSA, 9 non-protected and 3 were not labelled); vegetation class (8 lowland, 9 swamp, 3 bush and 5 agriculture); tiger presence (10 tigers, 3 tigers with cubs, 11 no longer have tigers but they were present within the last three years and 1 never had tigers); and prey-base (19 high, 1 medium and 5 low).

There were 12 HSA units labelled with the presence of tiger in the Way Kambas grid; 3 labelled as tigers with cubs and 9 with tigers.

There were 16 units labelled as HSA in the revised GIS database, totalling 1,600 km^2. However, Way Kambas is actually 1,300 km^2. This represents a 300 km^2 increase in the size of the park. The discrepancy can be attributed to units that overlapped the ocean (364 km^2). While the area of the park is overestimated, the goal is to approximate where tigers are distributed.

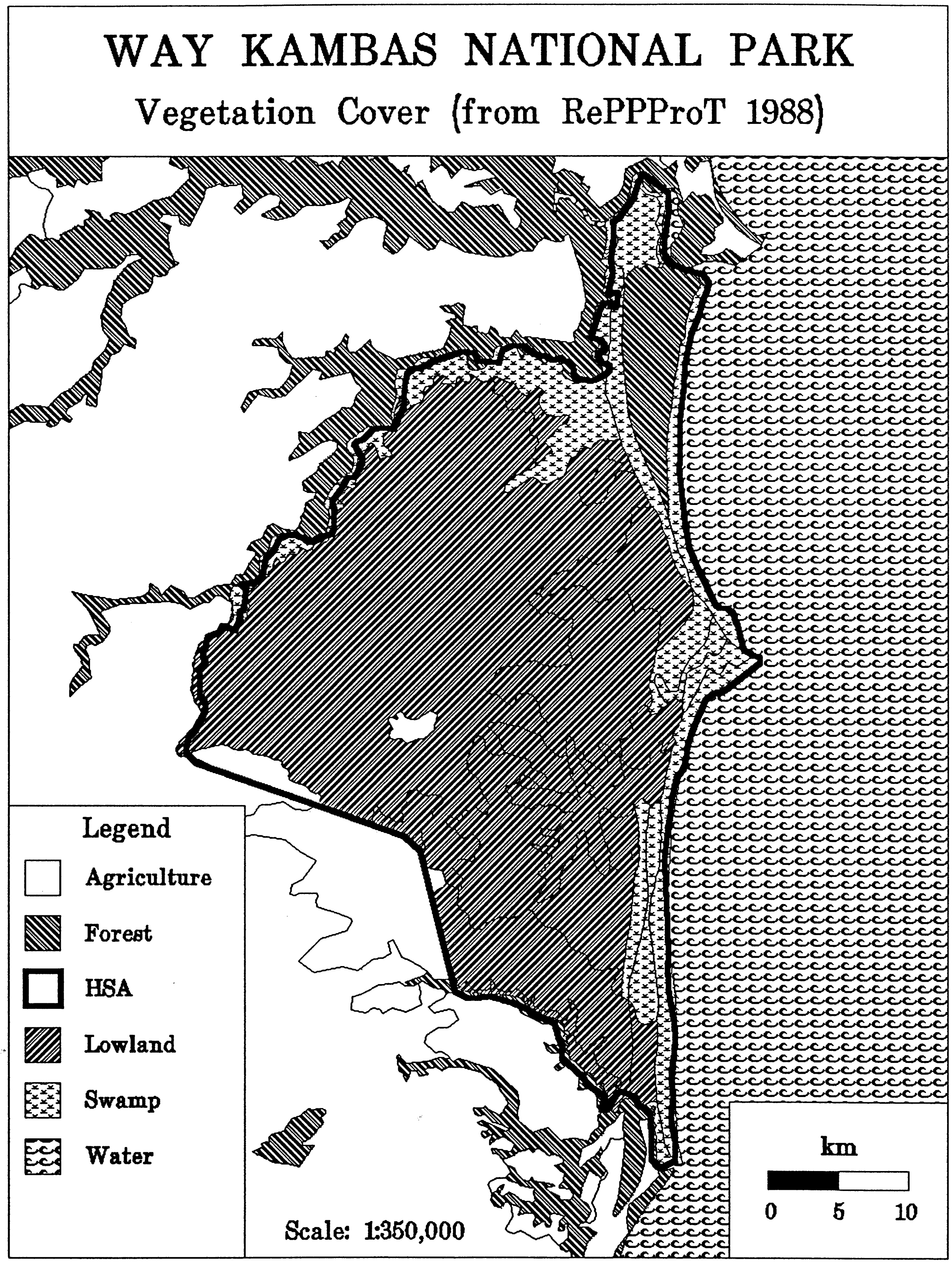
There is a discrepancy between the area of bush in the GIS database (RePPProT 1988) and in the grid as revised by the working group (800 km^2 GIS, 300 km^2 grids). This corresponds with a discrepancy between the same two databases in the amount of lowland forest (200 km^2 from GIS database, 700 km^2 from the revised grid). The RePPProT (1988) maps came from older satellite data; thus much of the area listed as bush in the GIS database is now secondary forest (70% of Way Kambas was logged in the 1960's and 70's).

<u>Tiger estimates from vegetation in GIS database (data from vegetation analysis):</u> There are 1,295 km^2 of lowland, swamp and bush in the park (agriculture has been excluded because of its small size), for an estimated 7-8 male and 14-15 female tigers. The population size from the GIS vegetation analysis was estimated between 21-23 individuals.

<u>Tiger estimates from HSA areas (from data received at the PHVA workshop):</u> All 12 units labelled for tigers had lowland, bush or swamp, for an estimated 6-7 male and 13-14 female tigers. The total population was estimated at 19-21 tigers.

Table 11. Vegetation analysis of Way Kambas National Park (1300 km^2, from RePPProT 1988).

Vegetation type	Area (in km^2)
Lowland	198
Bush	804
Swamp	293
Agriculture	19


WAY KAMBAS NATIONAL PARK
Vegetation Cover (from RePPProT 1988)
Legend
Agriculture
Forest
HSA
Lowland
Swamp
Water
Scale: 1:350,000
km
0
5
10

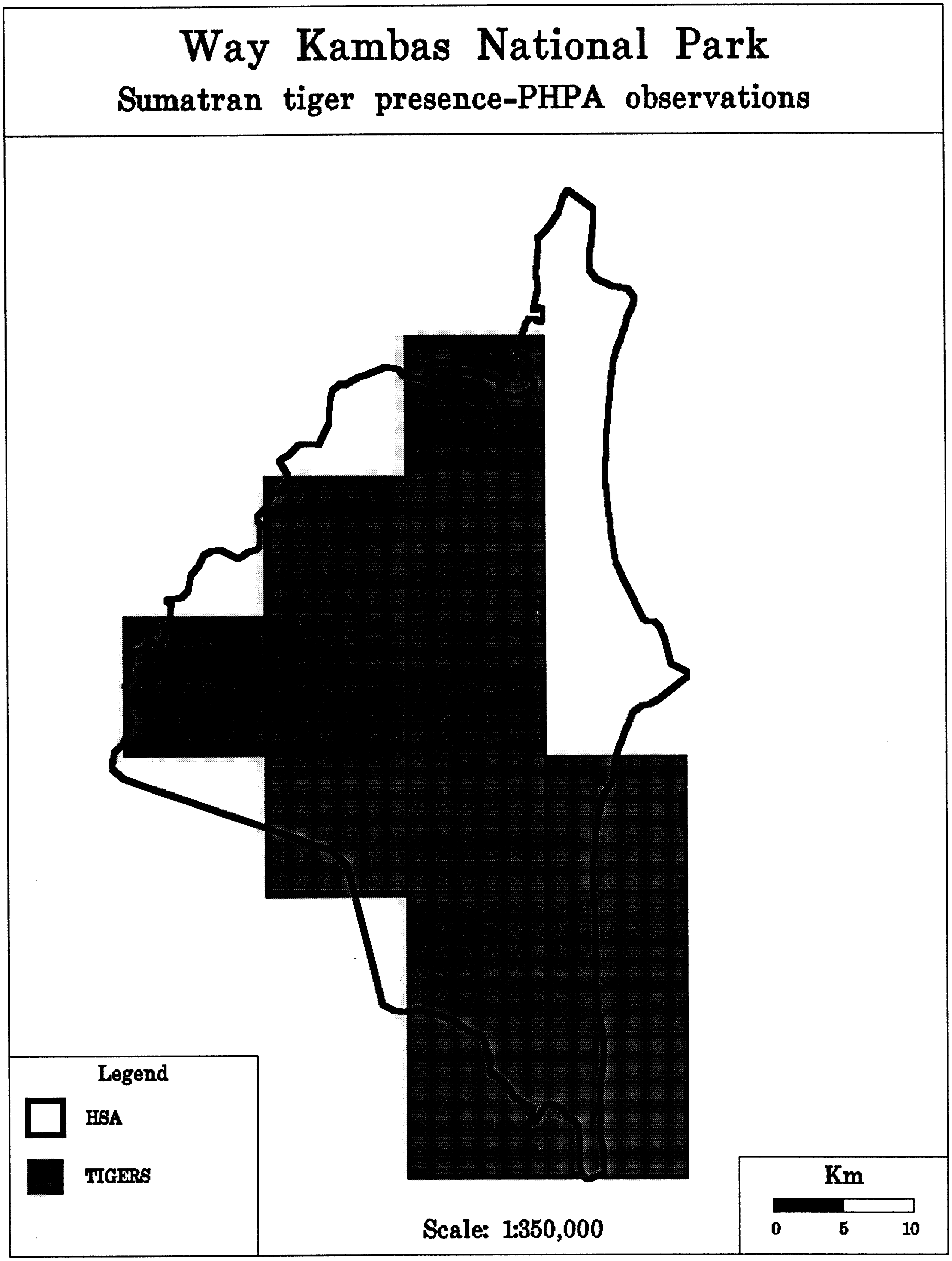

Way Kambas National Park
Sumatran tiger presence-PHPA observations
Legend
HSA
TIGERS
Scale: 1:350,000
Km
0
5
10

Table 12. Grid of Way Kambas National Park.

Land-use	Vegetation	Tigers	Amount of prey		
			H	M	L
HSA (16)	Ll (7)	T (4)	4	0	0
		T/C (3)	3	0	0
	Sw (7)	T (3)	2	0	1
		H (4)	2	1	1
	B (2)	T (2)	2	0	0
NP (9)	Ll (1)	T (1)	1	0	0
	Sw (2)	H (1)	1	0	0
		N (1)	1	0	0
	B (1)	H (1)	1	0	0
	Ag (5)	H (5)	2	0	3

Legend: Ll = Lowland forest, Sw = Swamp, B = Bush, Ag = Agriculture; T = Tiger presence, T/C = Tiger with cubs presence, H = Historical presence of tigers, N = No tigers within last five years.

Berbak National Park

There were 123 units in the Berbak database; only 13 were filled with any information. The only information received for the units was tiger presence.

Only 10 HSA grids were labelled for tiger presence; no other data were received. Berbak is a peat-swamp forest. Santiapillai and Ramono (1985) and Seidensticker (1986) estimated that this type of forest cannot support a high prey-base, thus it was poor tiger habitat. However, Santiapillai and Ramono (1985, 1987) have suggested that Berbak has a large number of tigers, and therefore consider Berbak to be an important reserve. There is little information available on the distribution of tigers in Berbak. Based on the literature, tigers utilize all of the vegetation types within the park. We will therefore assume that tigers occupy the entire park.

Recently, Berbak was changed from a game reserve to a national park. When this occurred the size of the park was reduced. The park was originally 2,447 km^2 and is now 1,716 km^2.

Tiger estimates from vegetation in GIS database (data from vegetation analysis): Using the vegetation types that occur within current park boundaries, there are 120 km^2 of swamp and logged forest. This results in an estimate of 1 male and 1-2 female tigers. There are 1,517 km^2 of peat-swamp forest, for an estimate of 5-6 male and 11-12 female tigers. The total estimated population for Berbak is between 18-21 tigers, 6-7 males and 12-14 females.

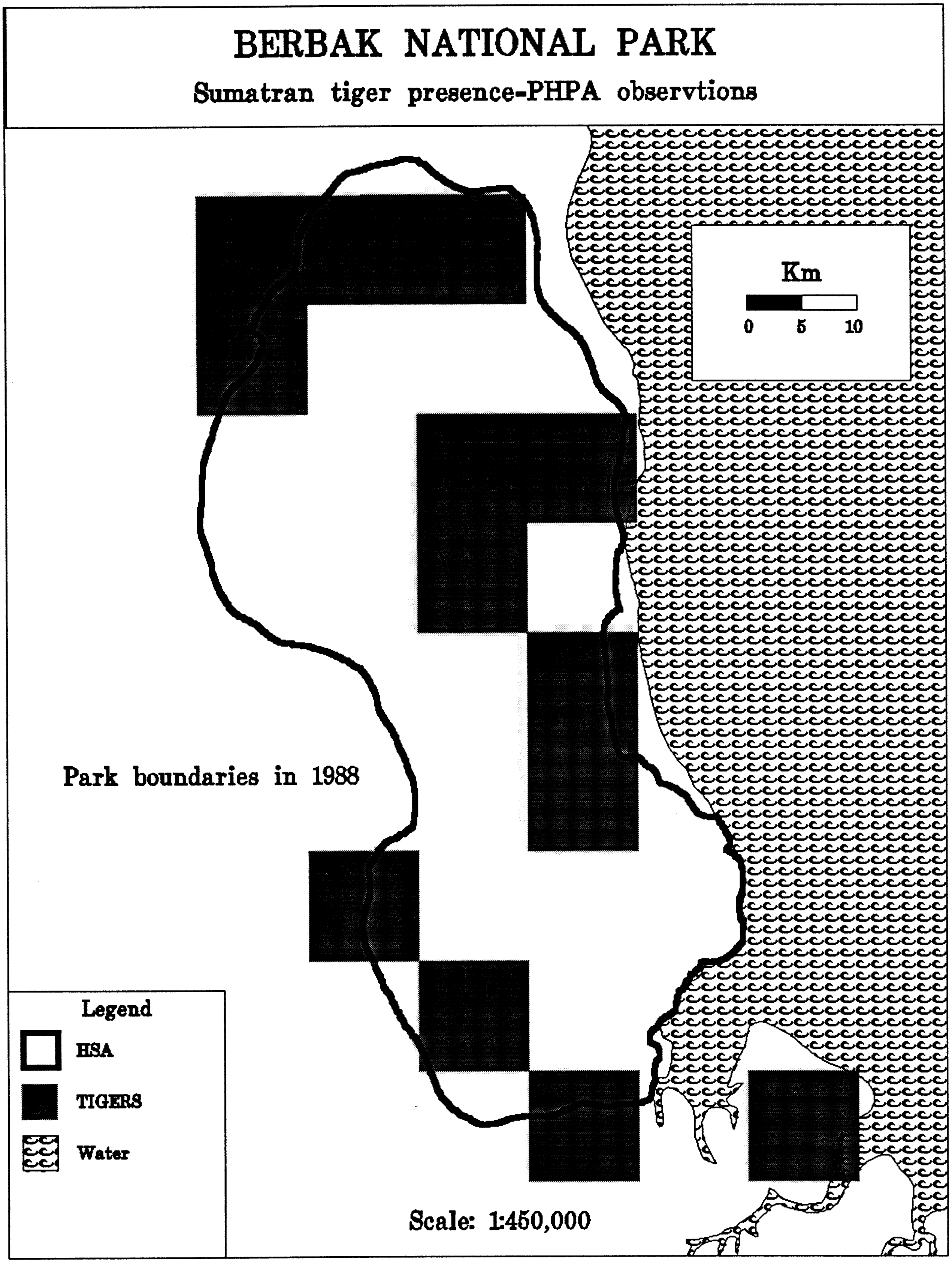
Table 16. Vegetation analysis of Berbak NP (1,716 km^2, from RePPProT 1988).

Vegetation type	As G.R. (km^2)	Currently (NP) (km^2)
Swamp	393	115
Peat Swamp	1,863	1,517
Agriculture	186	75
Logged	5	5

Table 17. Grid of Berbak National Park.

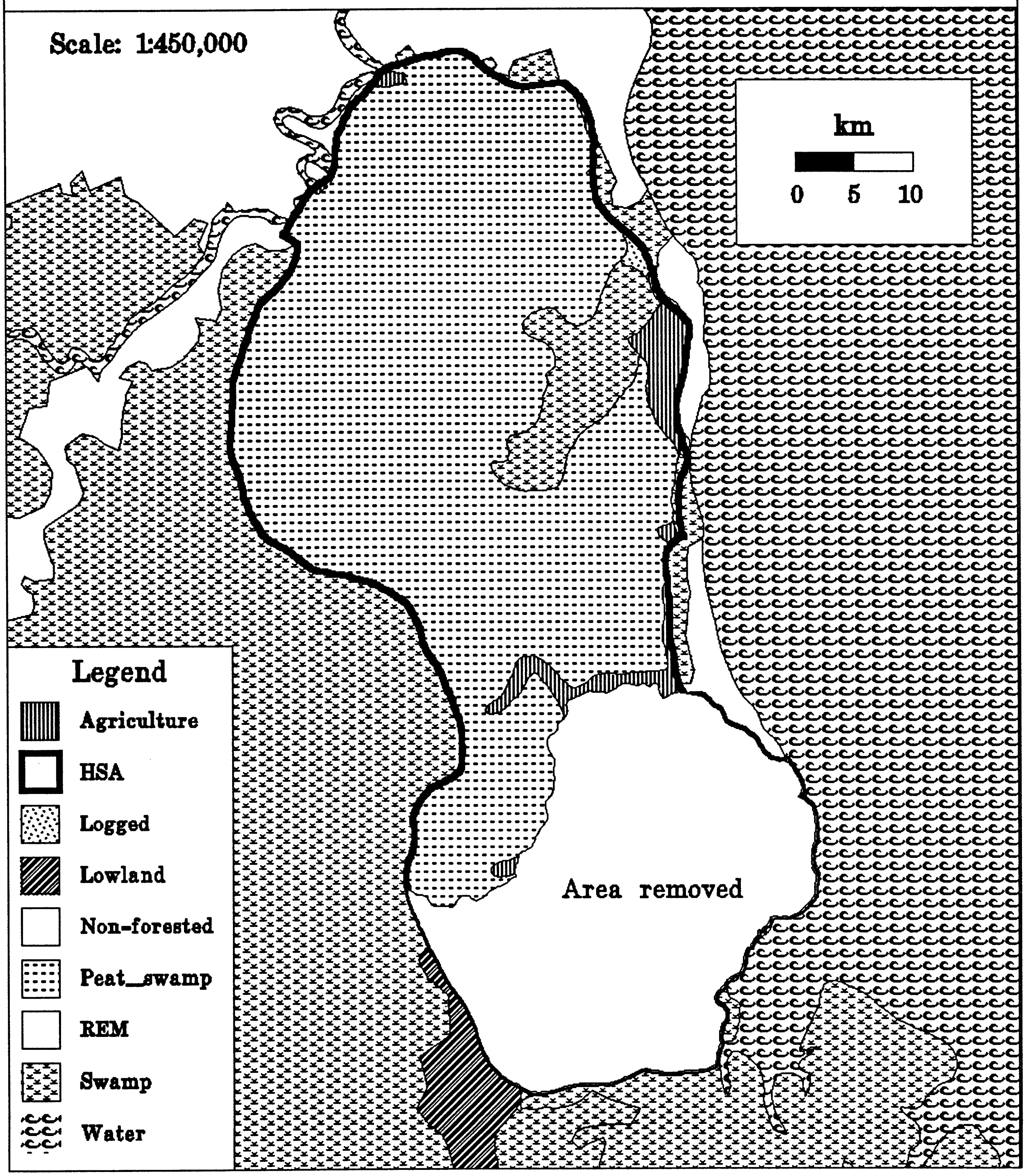
Land-use	Vegetation	Tigers	Amount of prey			
			H	M	L	NL
HSA (11)	Sw (11)	T (11)	0	0	0	11
HL (1)	Sw (1)	T (1)	0	0	0	1
NP (1)	Ag (1)	T (1)	0	0	0	1

Legend: Sw = Swamp, Ag = Agriculture; T = Tiger presence; NL = Units not marked for amount of prey.


BERBAK NATIONAL PARK
Sumatran tiger presence-PHPA observtions
Km
0
5
10
Park boundaries in 1988
Legend
HSA
TIGERS
Water
Scale: 1:450,000

BERBAK NATIONAL PARK

Vegetation cover (from RePPProT 1988)



TIGER MANAGEMENT OUTSIDE OF HSA AREAS

Protection (HL) and certain classifications of production forest are intended to be managed with forest cover intact. If this occurs then the assumption that only HSA areas should be considered as tiger management areas needs to be reevaluated. These areas currently have tigers and in the case of production forest, logging may improve an area as tiger habitat. Therefore, the role of protection and production forest in the maintenance of viable populations of tigers needs to be examined around Kerinci Seblat (data for areas adjacent to the other parks are unavailable).

In addition to tiger areas within Kerinci Seblat, there are 67 units with tiger presence in protected status other than HSA (34 HL and 33 HPT). Of the 34 HL, two units are labelled with the presence of tigers with cubs (1 bush and 1 agriculture) and 32 units are labelled with tigers (20 lowland, 4 submontane and 8 agriculture). There are 33 units labelled with HPT. One unit is labelled tiger with cubs (submontane). The other 32 units are labelled for tigers (3 submontane, 16 lowland, 11 agriculture and 2 bush).

All areas are connected or potentially connected by suitable habitat to tiger areas within Kerinci Seblat, and thus represent potential areas that could be managed for tigers to enhance the present tiger population. HL areas have an estimated 14-17 male and 29-32 female tigers. HPT areas have an estimated 13-15 male and 27-29 female tigers. We previously considered our analysis within Kerinci Seblat to be an overestimate, based on numbers provided at the workshop. The estimations outside of HSA areas may likewise be overestimated. However, regardless of actual numbers these areas can be important to the overall viability of Kerinci Seblat's tiger population.

Table 18. Summary of tiger population estimates for five protected areas.

Protected Area	Vegetation analysis			Tiger distrib. from plots			PHVA
	M	F	Total	M	F	Total	Total
Barisan Selatan	16-18	33-35	49-53	9-13	18-22	27-35	68
Berbak	6-7	12-14	18-21	6-7	12-14	18-21	50
Gunung Leuser	36-39	74-77	110-116	33-36	69-72	102-108	110
Kerinci Seblat	44-47	89-92	133-139	40-41	80-82	120-123	76
Way Kambas	7-8	14-15	21-23	6-7	13-14	19-21	20
Kerumutan	-	-	-	-	-	-	30
Rimbang	-	-	-	-	-	-	42
Totals			339-361[a]			268-287[a,b]	396

[a] Does not include other parks with tigers (Rimbang and Kerumutan)

[b] Includes estimates from vegetation analysis of Berbak National Park.

FUTURE DIRECTIONS

The results and analysis presented here provide a beginning, not the final result, of a commitment to ensure the long-term viability of free-ranging Sumatran tigers. As such, there are several issues that need to be further explored to gain better estimates of tiger distribution and densities. Within the context of this paper, these include: expansion of the database to include all viable tiger habitats, including both protection and production forest; identification of unsuitable habitat within these areas; better estimation of tiger home range sizes in tropical rain forest habitat; and better evaluation of the threats to wild tiger populations.■

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ESTIMATING POACHING AND REMOVAL RATES OF TIGERS IN SUMATRA

Ronald Tilson and Kathy Traylor-Holzer

"Poaching and illegal trade in tiger products are widespread throughout Asia. By their clandestine nature, both are difficult to detect. Poachers may bury tiger remains, including skins, if bones are the target. Unless there are sufficient forest guards, tiger carcasses are unlikely to be found and soon vanish. While skins can be easily identified, only a handful of experts can identify tiger bones, which can be readily transported and mistaken for other (legitimate) animal bones, in which there is normal trade" (Jackson, 1993). Tiger products are being sold in local markets in Laos (Martin, 1992), Vietnam (Jackson, 1993), and Thailand (Rabinowitz, 1993), and trafficking of tiger products has been documented in India and Nepal (Jackson, 1993) and in Indonesia (Mills, 1993; Anonymous, 1994). Outside of tiger range countries, large numbers of bones and other tiger products have been found in Taiwan (Nowell, 1993) and South Korea, many of which were from Indonesia (Mills, 1993). It is China, however, by virtue of its large population, is the largest consumer and producer of manufactured medicines containing tiger parts (Nowell, 1993; Linden, 1994).

Opinions differ on how exactly poaching and the illegal trade in tiger products impact wild populations. In recent years increased poaching levels have been documented in India, Nepal and the Russian Far East, and the consumption of tiger products in China, Taiwan and South Korea continues unabated (Jackson, 1993). The question is: From where did all of these tiger parts originate? No one knows for sure from where or at what rate tigers are being removed from the wild. The general consensus, however, is that the free-ranging populations across Asia are decreasing, and unless poaching is stopped, or at least the demand for tiger products (which contributes to poaching) is stopped, these numbers will continue to decrease.

At the Sumatran Tiger PHVA Workshop we attempted to quantify this information in regards to Sumatra and Sumatran tigers. We have a number of sources to evaluate that provide some indication of how many tigers are being lost to poaching and poisoning, as well as how many tigers are being officially removed by PHPA when they come in conflict with local villagers. These sources are:

Official PHPA Reports:

- At the PHVA Workshop, PHPA staff estimated that, on average, about 17 incidents involving problems with tigers are reported every year from the five national parks of Sumatra. Of these 17 instances, PHPA reported that about 12 resulted in tiger losses; about six through poaching or poisoning and another six through official removal by PHPA (see Vortex section of this report). These estimates are only for the five national parks of Sumatra and do not include other instances involving tigers living in much smaller and fragmented forest patches designated as game reserves or protection (and production) forests.

- The Indonesian Ministry of Forestry requires registration permits for all persons keeping endangered species. The initial registration period was to extend from February through May of 1992 (Decree No. 301/Kpts-II/1992) but was extended to October 1992 (Decree No. 479/Kpts-VI/1992). A total of 1,081 mounted tigers were reported to have been registered at the time of the PHVA workshop (*Conservation Indonesia*, 8(3), 1992). The origin of these tigers was undetermined, but presumably they were from Sumatra originally, or were captive-born offspring from either wild-caught or privately-held tigers.

- Registered tiger specimens included 100 stuffed Sumatran tigers kept in houses of government officials and businessmen in South Sumatra. Another 200 stuffed tigers are held by private individuals in Lampung and about 300 in Palembang (*KOMPAS*, 1 June 1992).

International Trafficking Reports:

- South Korean customs administration statistics show that, between 1975 and 1992, South Korea imported 3,720 kg of tiger bones from Indonesia. Traders in Southeast Asia report that the amount of dried tiger bones from a single tiger ranges from 6-11 kg, which implies South Korea imported the equivalent of 338-620 tigers over the 18-year period. In fact, Indonesia accounted for 61% of the total tiger bone import (6,128 kg) for South Korea (Mills, 1993, *Cat News* No. 19).

  In the last three years alone (1991-1993), 475 kg, or about 20 tigers annually, were exported to South Korea (Mills, 1993, *Cat News* No. 19).

- Tiger bone is an important ingredient for nine South Korea companies in the manufacture of pharmaceutical products. As of 15 October 1992 the *East Asian Medical Journal*, a South Korean bi-monthly newspaper, carried a full-page price list for Chin Hyung Dried Medicine Materials Company listing tiger bone at US$ 1,600/kg (3.3 million Rp/kg) (Mills, 1993, *Cat News* No. 19).

- In Singapore the retail price for a well-tanned adult Sumatran tiger skin is about US$ 2,000 (4.1 million Rp). The retail price for a Sumatran tiger penis is US$ 100 (Martin, Chen and Lin, 1991, *International Zoo News* No. 229).

- In 1993, Traffic International reported that a number of tiger bones were exported from Indonesia to Taiwan and China. Although the amount could not be confirmed at the time of this report, it was reputed to be substantial.

Published Reports:

- In the last decade a number of newspaper reports appeared in *The Jakarta Post* concerning tigers harassing villagers and killing their cattle. In South Aceh province, North Sumatra, a tiger killed and devoured a man and dozens of cows, goats and sheep. In West Aceh province a tigress killed a teenager and dozens of cattle before it was caught by PHPA. Local *pawangs* (traditional tiger charmers) were quoted as having successfully trapped 64 live tigers over several months (*The Jakarta Post*, 1984-85).

- Since 1986 extensive poaching of tigers has been carried out along the forest edge in Gunung Leuser National Park, North Sumatra, especially in the west where the animals have been killed using poisoned baits. Estimates vary as to how many tigers have been killed in this period, but second-hand accounts from the leading poacher indicate as many as 50 tigers were killed between 1986 and 1990. Tiger numbers on the forest edge (much of which is still outside the park) have decreased and now pig numbers (that used to be controlled by tigers) have increased with subsequent loss of crops (Griffiths, this report).

- In a report on Berbak National Park, it was stated that an average of one tiger has been killed in the vicinity of the park each year for the past eight years, according to one PHPA staff member, and three tigers are known to have been poached in 1991 (Frazier, this report).

- In Kerinci, central Sumatra, several traditional methods are used to kill a guilty tiger [one that has killed livestock or humans]. Most widespread is a type of pit trap, consisting of a slowly tilting plank set over a pit. Under the plank, sharp bamboo sticks (*ranjau*) are firmly planted in the ground. When the tiger walks on the plank and gets the bait, the plank will drop and the bamboo sticks will spear the tiger in its belly. Another method involves using a snare in the form of a slipknot from bamboo. From the time firearms were introduced in the region, probably by the Dutch at the beginning of the century, local hunters have used these to kill tigers. Hunters waited with lamp and gun in trees above the remains of the animal killed by the tiger. In several cases Dutch and later Indonesian policemen were asked to kill the tiger (Bakels, this report).

  In Kerinci there is no tradition of building cages to catch tigers, as is done by the neighboring Minangkabau in West Sumatra. In some recent cases a Minangkabau tiger charmer (*pawang harimau*) was involved in Kerinci and caught a tiger in a cage. Local Kerinci inhabitants spoken to absolutely denied they would ever try to catch an innocent tiger [one with no history of attacking livestock or people] (Bakels, this report).

- A much older article reported that on 19 January 1981 a team of PHPA officials and West Sumatran police raided the home of a taxidermist in Padang Panjang, West Sumatra, who, for several years, had been preparing and mounting skins given to him by poachers. The team confiscated 29 tiger skins taken from the forests of Sumatra, including six mounts, eight processed flat skins, and 15 fresh tiger skins still being processed (*Conservation Indonesia*, 5(1), 1981).

Word-of-Mouth Reports:

- A former poacher interviewed in Padang, West Sumatra in 1992 confirmed the relative ease and speed with which tigers are ferried into Singapore. An earlier report of Sumatran tiger skins for sale in Singapore surfaced in 1988, when a British journalist was offered tiger skins and told he could be supplied with 10 pelts per month, mostly from Sumatran tigers (Earthtrust, 1993).

- In 1993, at least two tigers were reportedly killed by police in villages just outside of Kerinci Seblat National Park, central Sumatra (Anonymous, 1993).

- In 1993 a restaurant in the city of Pekanbaru, South Sumatra, offered tiger meat to a group of Chinese tourists as one of its courses (Anonymous, 1993).

- A taxidermist (and possible trafficker) interviewed in Jakarta in 1994 offered a complete Sumatran tiger skin (reputedly wild-caught from Jambi, South Sumatra) for US$ 2,500 (5 million Rp), which included an official permit from PHPA legally registering this specimen in Indonesia. The tiger skin without the permit would have only cost US$ 500 (1 million Rp). He also offered a plastic sack of tiger leg bones for US$ 250/kg (300,000 Rp) as well as claws and canine teeth from tigers for US$ 20 (40,000 Rp) each. This individual stated that most of his customers were from Thailand or South Korea (Anonymous, 1994).

Television Documentary:

- In 1988 Cinecontact Productions produced a video called "Animal Traffic: 31 Tigers". It documented the poaching of a wild tiger somewhere in Sumatra using a wire snare. The poacher reputedly had already caught 30 tigers in the past year; this program documented his 31st. An Indonesian taxidermist in the video claimed to have sold 10 tiger skins within the last year. The narrator estimated that the 9-10 tiger poachers operating at that time in Sumatra could kill up to 200 tigers per year.

REMOVAL OF PROBLEM TIGERS BY PHPA

From time to time wild tigers causing problems for local villagers (primarily by killing and eating their livestock) are captured by PHPA and transferred to Indonesian zoos. Many of these tigers constitute the genetic founders of the Indonesian Zoological Parks Association (PKBSI) Sumatran Tiger Masterplan. The current Indonesian Sumatran Tiger Studbook (1994) lists a total of 30 (18 living) reputed wild-caught tigers from Sumatra (captured from 1965-1992). These tigers, which are outside of the boundaries of the protected areas, need to be removed by PHPA; if not, more than likely they will be poisoned or killed by villagers.

ESTIMATE OF IMPACT ON WILD POPULATIONS

It is almost impossible to estimate how many tigers are being lost to poachers, how many are being killed by poison, and how many are dying naturally. Currently we only have records of tigers that have been caught by PHPA and transferred to the PKBSI for captive breeding and a few reports of tigers being killed by police or other individuals in and around villages. In summary, we attempt to estimate the magnitude of these tiger losses based upon the following logic:

- Fact: PHPA reports that about six tigers per year are legally removed from the wild; these tigers are either killed or are captured and transferred to the PKBSI Sumatran Tiger Captive Program.

- Fact: PHPA officially reports another six tigers are lost annually from the five national parks through poaching.

- Supposition: If the official PHPA registry reports are correct (and assuming these represent tigers mounted over the past 10, 20, or 30 years), this suggests that these taxidermic mounts represent either 36, 54, or 100 tigers per year were poached, depending on the time span.

- Supposition: If the South Korea imports of tiger bones from Indonesia were derived solely from wild tigers, this would account for 20 tigers being poached per year (over the last three years). This does not take into account tiger bone exports to Taiwan, Thailand or China.

- Conclusion: From these numbers, we conservatively estimate that a minimum of 42 tigers are lost annually from the wild population. This minimum number is derived from the following: 6 problem tigers that are removed by PHPA, and 36 tigers poached for taxidermic mounts.

This rate of removal takes into consideration that tiger bone exports may have been derived from the same tigers that were reported as taxidermic mounts or skins. This conservation rate of removal assumes that the taxidermic mounts were obtained at a constant rate and are applicable to the last several years. Also, it is difficult to reconcil historical rates with current rates of removal. Finally, not all of these tigers were necessarily wild-caught; some may have been derived from captive-born animals from the private sector.

However you interpret this information, one unescapable conclusion is that tigers are being lost from the wild, and that tiger products are leaving Indonesia and entering the pharmaceutical industry elsewhere in Asia. Vortex modelling (see Vortex section of this report) suggests that losses of wild tigers at the above rate will reduce even relatively large wild tiger populations, such as those in Gunung Leuser and Kerinci Seblat National Parks, to non-viable levels.■

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POPULATION BIOLOGY AND ANALYSES FOR SUMATRAN TIGERS

Ulysses Seal, Komar Soemarna and Ronald Tilson

INTRODUCTION

The tiger population on Sumatra is fragmented and isolated in 5-12 reserves and surrounding unprotected areas. Migration between some of these areas may be possible based upon the presence of forested corridors. However, no natural migration is possible among the five National Parks, so that the tiger populations in each now must function and be managed as separate genetic and demographic population units.

These small and isolated tiger populations are at risk of extinction from the interaction of random and deterministic processes (e.g., skewed sex ratio, failure to locate mates, disease, genetic drift, inbreeding depression, fighting, reduction in populations of prey animals, poaching, and poisoning). These populations and their habitat will require intensive management if the Sumatran tiger is to survive in the national parks for even 50 to 100 years.

The need for and effects of intensive management strategies can be modelled to suggest which practices may be the most effective in preserving the individual tiger populations. A stochastic population simulation modeling package, VORTEX 6.2 written by Robert Lacy and Kim Hughes was used as a tool to study the interaction of multiple variables treated stochastically to gain assist a better understanding of the effects of different management manipulations.

The VORTEX program is a Monte Carlo simulation of the effects of deterministic forces as well as stochastic demographic, environmental, and genetic events on wildlife populations. VORTEX models population dynamics as discrete, sequential events (e.g., births, deaths, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or as random variables that follow specified distributions. VORTEX simulates a natural population by stepping through the series of events that describe the typical life cycle of sexually reproducing, diploid organisms.

VORTEX is not intended to give absolute answers, since it is projecting stochastically the interactions of the many parameters which enter into the model and because of the random processes involved in nature. Interpretation of the output depends upon knowledge of the biology of the Sumatran tiger, the conditions affecting each of the individual populations, and possible changes in the future. The output is constrained by the input. Where needed input data are not available or uncertain, data from other tiger populations or best guesses by tiger experts were provided as input. The results from the simulations can be used to suggest the most critically needed data to provide more reliable results and thus assist the design of needed research for management of the populations.

MODEL INPUT

Tiger natural history data used for the VORTEX model (Tables 1, 2, 5, 6) were taken from published studies on the *Panthera tigris tigris* in the Royal Chitwan National Park (Smith, 1992, pers. comm.), unpublished data contributed by the workshop participants (see Wiese et al., this report), information from people working in the individual Protected Areas, and information from the studbooks for captive tiger populations.

Carrying Capacity: Carrying capacity or K defines an upper limit for the population size, above which additional mortality is imposed in order to return the population to K. In other words, VORTEX uses K to impose a ceiling model of density-dependence on survival rates.

Habitat size and prey availability (density) are indicators of carrying capacity of the respective Parks and surrounding areas. Estimates of possible and probable tiger population numbers (animals 1 year and older) in the respective protected areas ranged from 25 to 150 animals. There are areas with fewer than 25 tigers but it is unlikely that any of the protected areas will sustain more than 150 animals. Therefore, 4 carrying capacities of 25, 50, 100, and 150 tigers to encompass this range were included in the sets of scenarios simulated (Table 4).

We did not include any trends in carrying capacity over time since the range was encompassed by the K values used. We also did not include any annual variation in K since this is unknown for these areas and such changes tend to have minimal effects on large carnivore populations (as opposed to sustained changes).

Age First Reproduction: VORTEX defines breeding as the time when young are born, not the age of sexual maturity. VORTEX also assumes discrete intervals of years in the case of tigers. For tigers on average the age of first reproduction in wild populations appears to be 3 years for females and 4 years for males although younger animals in captivity can breed. These values were used in all of the simulation scenarios. The breeding structure was assumed to be polygynous.

Litter Size: Environmental variation in reproduction is modelled by entering a standard deviation (SD) for the percent of females producing litters each year (Tables 5, 6). VORTEX then determines the percent breeding each year of the simulation by sampling from a binomial distribution with the specified mean (e.g., 50%) and SD (e.g., 12.5%). Thus about 66% of the time, the percent of females breeding will fall within ± 1 SD of the mean; about 95% of the time it will fall within ± 2 SD of the mean. The relative proportions of litters of each size (1, 2, 3, etc.) are kept constant; what is varied from year to year is the percent breeding (litter size > 0) and the percent not breeding (litter size = 0).

The maximum litter size observed in wild tigers is 5 cubs (also litters with more than 5 cubs comprise less than 2% of captive litters). Most information on wild tiger litter sizes is based upon observation of cubs 3-6 months of age and thus does not represent birth litter sizes. Data on *P. t. tigris* indicate mean litter sizes of 3 at this age. Limited field observations in Sumatra indicate a mean of 2 cubs at about 6 months of age. We therefore made litter size one of the variables included in all of the systematic comparisons using mean litter sizes of 2 or 3 (Table 2, Table 4, column headed 'Lit # Mean'). The distributions of litter sizes for the respective means were set as follows:

Table 1. Distributions of litter sizes used in the scenarios to achieve a mean litter size of either 2 or 3 with 50 % of females producing no litter each year.

Mean litter# =	2	3
Size 0=	50%	50%
Size 1=	10	0
Size 2=	30	12
Size 3=	8	29
Size 4=	2	8
Size 5=	0	1

The proportion of females breeding each year determines the mean interbirth interval. This interval is reported to be 2 years in wild tigers so that 50% of adult females, on average do not produce litters each year. A modest amount of annual variation was included using a standard deviation of 12.5%. The sex ratio at birth is taken as equal (0.50 proportion of males) based upon observations of more than 500 litters in captive populations.

Males Breeding: The breeding system modeled by VORTEX assumes that mates are randomly reshuffled each year and that all animals that can breed have an equal probability of breeding. A proportion of the males - 50% - were excluded from the breeding pool in a given year in the base scenarios to reflect the fact that some males are excluded from breeding by the social structure.

Two conditions for males were modelled. The one used for most scenarios, allowed only 50% of the adult males to be in the breeding pool. Because of concerns that for small populations the number of males might be limiting reproduction by females and thus increase the probability of extinction, if the adult male population dropped to one animal, we also did a set of simulations for K=25 with all adult males in the breeding pool (compare files A18-A25, A54-A57 with similar numbered files without the 'A' prefix in Table 4). This set of simulations also allowed estimation of the impact of this restriction on males breeding on the rate of loss of genetic heterozygosity in the small population.

Age of Senescence: VORTEX assumes that animals can breed (at the species typical rates) throughout their adult lifespans. The maximum life expectancy is not used if the species does not reproduce throughout its entire life. This age was estimated as 15 years for wild tigers based upon several known age animals in Nepal and this value was used in all of the scenarios. Reproduction in captive female tigers appears to decline after 12 years of age.

Mortalities: Mortality as a percent (between 0.0 and 100.0) may be entered for each age class of immature females and males. Once reproductive age (adult) is reached, the annual probability of mortality remains constant over the life of the animal in these models and is entered only once. The mortality schedule used in all of the scenarios for the Sumatran tigers is drawn from the data on *P. t. tigris* in Nepal.

Table 2. Mortality schedule for females and males of immature and adult age classes, with standard deviations calculated from the field data with values as %).

Age	Females	Males
0 - 1	35 ± 16%	35 ± 16%
1 - 2	15 ± 10	15 ± 10
2 - 3	40 ± 15	30 ± 11
3 - 4		30 ± 15
Adults	10 ± 5	20 ± 8

Inbreeding: A population with the level of inbreeding depression of one lethal equivalent per diploid genome may have one recessive lethal allele per individual (as in the Recessive Lethals model in VORTEX); or it may have two recessive alleles per individual, each of which confers a 50% decrease in survival; or it may have some combination of recessive deleterious alleles which equate with one fully lethal allele per individual. Natural selection does not remove deleterious alleles at heterotic (or over-dominant) loci (because all alleles in this model are partly deleterious when homozygous), thus the effects of inbreeding are unchanged during repeated generations of inbreeding. The default number of lethal equivalents for the Heterosis model is 3.14 which is a median value obtained in a study of 40 mammalian species (Ralls et al. 1988).

Inbreeding depression has been observed in inbred lines of captive Siberian tigers (*P. t. altaica*). Negative impacts of inbreeding on reproductive parameters has been documented for cheetahs, Asian lions, and Florida panthers (Roelke and O'Brien, 1993). To include this potential threat in these models the Heterosis model in VORTEX was used in which we entered the number of "lethal equivalents" as 3.14. The inclusion of inbreeding was varied systematically in the scenarios developed for the Sumatran tiger populations, Table 4, so that comparisons were made under identical conditions with this factor present or absent.

<u>Threats</u>: Major potential threats for the wild populations of Sumatran tigers include continued loss of habitat, increasing fragmentation of remaining habitat, reduction of prey species density, removal of tigers for control purposes, and poaching for bone and skin or other products. Wild tiger populations, perhaps because of their relative isolation and thin distribution, are not known to have been affected by epidemic disease.

The impact of habitat loss has been modelled by using different carrying capacities as a guide to the changing risk of extinction with decreasing population size. Removals, on a continuing basis were modelled by using the harvest module of VORTEX with either 0, 2 or 4 adult tigers, split evenly between the sexes, removed per year. This in effect is a systematic increase in annual adult mortality. Scenarios that included losses modelled as less frequent events (catastrophes) did not include these systematic harvests or removals.

<u>Catastrophes</u>: Catastrophes can be thought of as the extreme of environmental variation. Catastrophes are events that impact either reproduction or survival. Catastrophes can be habitat destruction, floods, fire, disease, poaching, etc. Catastrophes do happen and are very real considerations when attempting to model the fate of small populations. We define the impact of these catastrophes in terms of effects on reproduction and survival. A catastrophe may have occurred when a mortality rate is noted that is statistically higher than the normal variation. The reproduction and survival rates for catastrophe years are obtained by multiplying the (non-catastrophe) probability of reproduction or surviving by a severity factor. The severity factor ranges from 0.0 to 1.0. Entering 0.0 indicates a total loss of reproduction or survival for the population and 1.0 indicates that the catastrophe, if it occurs, will have no effect.

Catastrophes in wild tiger populations might include large scale fires (which they might escape but suffer the consequences of reduction in the prey base), abrupt forest removal, unusual declines in the prey population, and poaching for bone and skin or other products. Since poaching events tend to be more episodic, occurring at uncertain intervals we modelled separately the impact of events occurring on the average either at 5 (20% probability) or 10 (10% probability) year intervals. The event, in both cases, was given a severity effect of 0.90 on survival (about 10% additional loss of animals to the population, i.e. 2-3 animals in a population of 25-30 animals) and no effect on reproduction of the remaining animals. This may underestimate the negative effects on reproduction of the potential social disruption that may occur.

Table 3. SUMATRAN TIGER - DEMOGRAPHY

File	Lit # Mean	Catas	Inb H	Population Growth: Deter r	Stochastic r	Stochastic SD	100 Years: Pe	N	SD	He	Te
K=25, N=25, 50% Males Breeding, Inbreed=H & 3.14 LE											
018	3	N	N	.086	.054	.262	.404	20	6	.298	53
019	3	N	H	.086	-.006	.260	.944	11	6	.310	54
022	3	10%	N	.076	.042	.269	.494	19	6	.283	50
023	3	10%	H	.076	-.014	.267	.964	10	6	.299	48
020	2	N	N	.031	-.004	.252	.754	17	7	.298	45
021	2	N	H	.031	-.038	.252	.998	3		.278	42
024	2	10%	N	.021	-.016	.260	.840	16	7	.261	44
025	2	10%	H	.021	-.049	.264	1.00	-	-	-	35
K=50, N=25, 50% Males Breeding, Inbreed=H & 3.14 LE											
010	3	N	N	.086	.071	.209	.042	44	9	.541	42
011	3	N	H	.086	.019	.211	.324	26	14	.561	71
014	3	10%	N	.076	.058	.216	.058	41	28	.534	49
015	3	10%	H	.076	.002	.224	.546	21	14	.526	68
012	2	N	N	.031	.011	.209	.344	34	13	.514	54
013	2	N	H	.031	-.030	.224	.914	13	9	.551	59
016	2	10%	N	.021	-.002	.226	.514	31	14	.480	49
017	2	10%	H	.021	-.043	.241	.976	12	8	.564	50
K=100, N=75, 50% Males Breeding, Inbreed=H & 3.14 LE											
034	3	N	N	.086	.076	.184	.004	90	13	.779	34
035	3	N	H	.086	.051	.178	0	82	20	.775	-
038	3	10%	N	.076	.064	.191	0	89	16	.740	-
039	3	10%	H	.076	.035	.186	.02	65	26	.746	57
036	2	N	N	.031	.022	.172	.02	71	25	.744	72
037	2	N	H	.031	-.005	.184	.30	42	29	.722	79
040	2	10%	N	.021	.006	.188	.160	59	29	.676	53

041	2	10%	H	.021	-.029	.207	.70	28	24	.670	66
K=150, N=75, 50% Males Breeding, Inbreed=H & 3.14 LE											
026	3	N	N	.086	.076	.177	0	140	16	.830	-
027	3	N	H	.086	.058	.174	.002	129	24	.838	39
030	3	10%	N	.076	.065	.181	0	134	21	.825	-
031	3	10%	H	.076	.044	.176	.020	117	33	.828	70
028	2	N	N	.031	.021	.167	.028	110	35	.803	61
029	2	N	H	.031	-.000	.172	.182	69	43	.784	75
032	2	10%	N	.021	.009	.182	.110	100	41	.754	63
033	2	10%	H	.021	-.020	.191	.460	46	36	.744	72
K=25, N=25, Catas=20%, 0.9 Survival Severity											
054	3	20%	N	.065	.026	.277	.632	18	7	.270	50
055	3		H	.065	-.024	.278	.992	9	10	.398	44
056	2		N	.011	-.031	.271	.928	15	7	.341	41
057	2		H	.011	-.056	.271	1.00	-	-	-	33
K=50, N=25, Catas=20%, 0.9 Survival Severity											
046	3	20%	N	.065	.045	.224	.150	41	11	.522	51
047	3		H	.065	-.008	.235	.712	21	13	.523	65
048	2		N	.011	-.017	.237	.708	28	14	.496	49
049	2		H	.011	-.051	.247	.992	9	5	.399	45
K=100, N=75, Catas=20%, 0.9 Survival Severity											
070	3	20%	N	.065	.054	.193	.004	86	17	.723	86
071	3		H	.065	.021	.194	.118	58	28	.720	74
072	2		N	.011	-.010	.209	.418	55	29	.638	57
073	2		H	.011	-.040	.219	.838	17	13	.620	60
K=150, N=75, Catas=20%, 0.9 Survival Severity											
062	3	20%	N	.065	.055	.184	.004	131	23	.816	73
063	3		H	.065	.034	.180	.014	110	36	.808	78
064	2		N	.011	-.005	.191	.208	70	42	.713	65
065	2		H	.011	-.030	.203	.624	37	34	.713	69

All Males in Breeding Pool, K=25, N=25, H=3.14											
A18	3	N	N	.086	.053	.261	.388	20	6	.335	52
A19	3		H	.086	-.003	.259	.898	10	5	.391	56
A20	2		N	.031	-.000	.250	.732	16	7	.346	48
A21	2		H	.031	-.038	.253	.996	7	4	.445	42
A22	3	10%	N	.076	.043	.267	.494	19	6	.325	54
A23	3		H	.076	-.013	.268	.968	11	7	.349	50
A24	2		N	.021	-.017	.264	.878	15	7	.331	43
A25	2		H	.021	-.048	.261	1.00	-	-	-	38
All Males in Breeding Pool, K=25, N=25, H=3.14											
A54	3	20%	N	.065	.026	.277	.610	18	6	.316	51
A55	3		H	.065	-.025	.282	.994	11	11	.229	44
A56	2		N	.011	-.031	.275	.932	14	8	.336	40
A57	2		H	.011	-.059	.270	1.00	-	-	-	32

Age Distribution: We initialized all of the models with a stable age distribution which distributes the total population among the various age classes. The initial population sizes used were 25 for K=25 or 50 and 75 for K=100 or 150. VORTEX automatically enters values for all age classes, proportionate to the stable age distribution.

Base Models: Two basic models were constructed from the available life history data using mean litter sizes of either two or three cubs (column 2 in Table 3) with all other variables the same. The other parameters systematically varied were carrying capacity (25, 50, 100, 150), inbreeding depression (column 4 - present or absent using a heterosis model with 3.14 lethal equivalents), and catastrophes (column 3 - absent, or present with a frequency of 10 or 20% and a survival severity factor of 0.9).

The two basic models do not include effects of annual harvests, inbreeding depression, catastrophes, or further habitat degradation. The effects of these additional factors were systematically added to the basic models to evaluate their impact on the risk of extinction and population dynamics. These factors generally increase the probability of extinction, decrease surviving population sizes, and decrease the amount of genetic variation remaining in the simulated population.

RESULTS OF SIMULATION MODELLING

The simulation scenarios were run 500 times (iterations) with projections for 100 years. Output results are summarized at 10 year intervals in the reports for the individual scenarios and were the source of the data for the time series figures. Each individual scenario is identified with a file number in column 1 of the Table. The simulations were run using VORTEX version 6.2 dated 8 January 1994. This software and manual are available from the IUCN/SSC CBSG Office (12101 Johnny Cake Ridge Road, Apple Valley, MN 55124, USA).

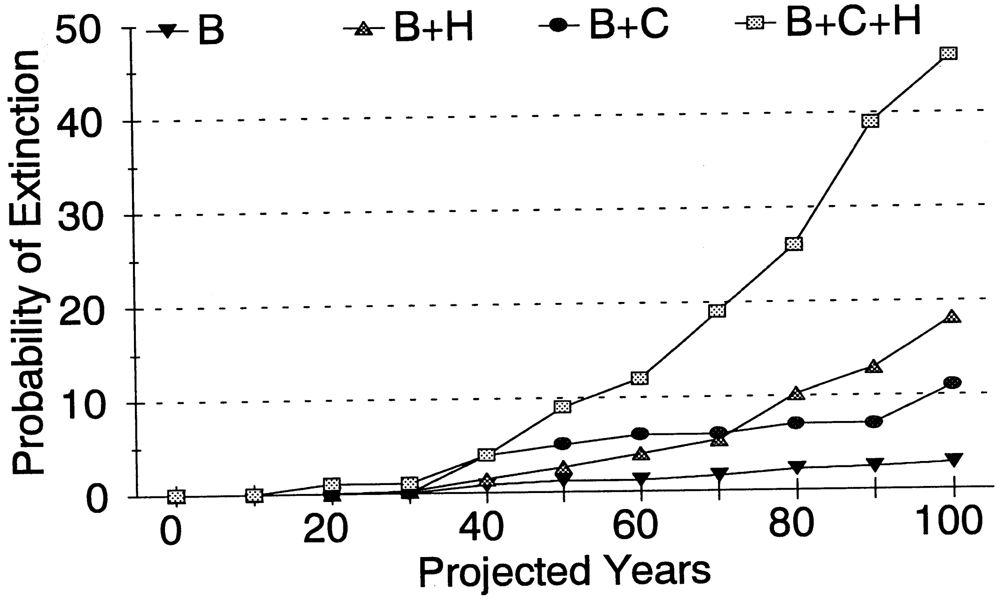
Deterministic Results

Growth rate - r: The deterministic growth rate (intrinsic rate of increase) calculated by a Leslie matrix algorithm is recorded in the 5th column in Table 3. Positive values are necessary for a population to survive and in principle a zero value would characterize a stable population which is neither growing or declining. Note in Table 3 that the deterministic growth rate is not sensitive to differences in carrying capacity or to the presence of inbreeding, or to the presence of environmental variance included as standard deviations in mortality and reproduction. The addition of a catastrophe does reduce the deterministic r since it is averaged into the calculations of the Leslie matrix.

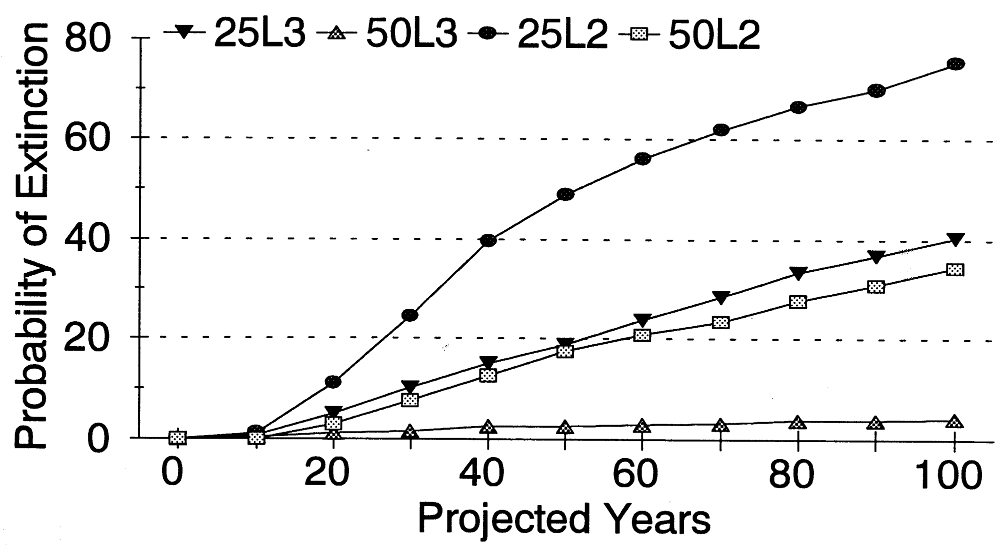
Other Deterministic Values: The generation times in most of the scenarios were about 7 years for females and 6.8 years for males (Tables 4 & 6). Thus a 100 year projection spans about 14 generations. The sex ratio of adult males to females in a stable population was calculated at 0.522. This value of about 1 adult male per 2 females reflects the combined effects of a one later age of first reproduction for males and the higher adult male mortality rate. Lambda is calculated from r and can be used for the % annual growth rate (i.e.: [lambda - 1.000] x 100 = annual % growth rate). A stable age distribution for each sex and age class is also presented. This will be the same regardless of K or H if the mortality and reproduction rates values are the same. These calculated age distributions are useful estimates for comparison with collected field data on population age structure as a check on the status of the population, on census methods or for detection of unusual events in the population.

SUMATRAN TIGERS PHVA

Interactions of L=2, K=150, H, & C10

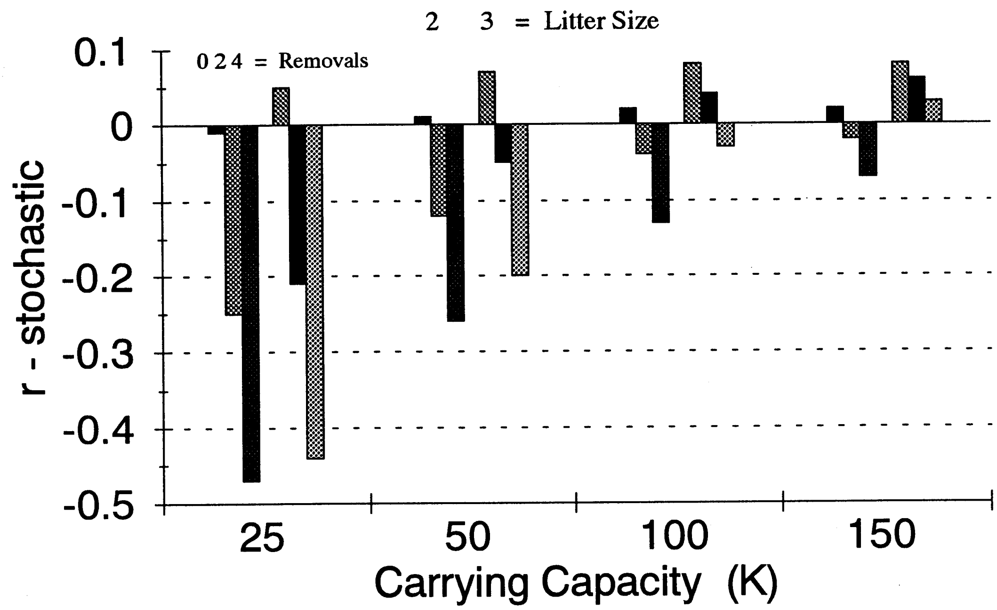


Effect of Litter Size and K



SUMATRAN TIGER DEMOGRAPHY

Effects of Litter Size & Removals



Effects of Litter Size & Removals

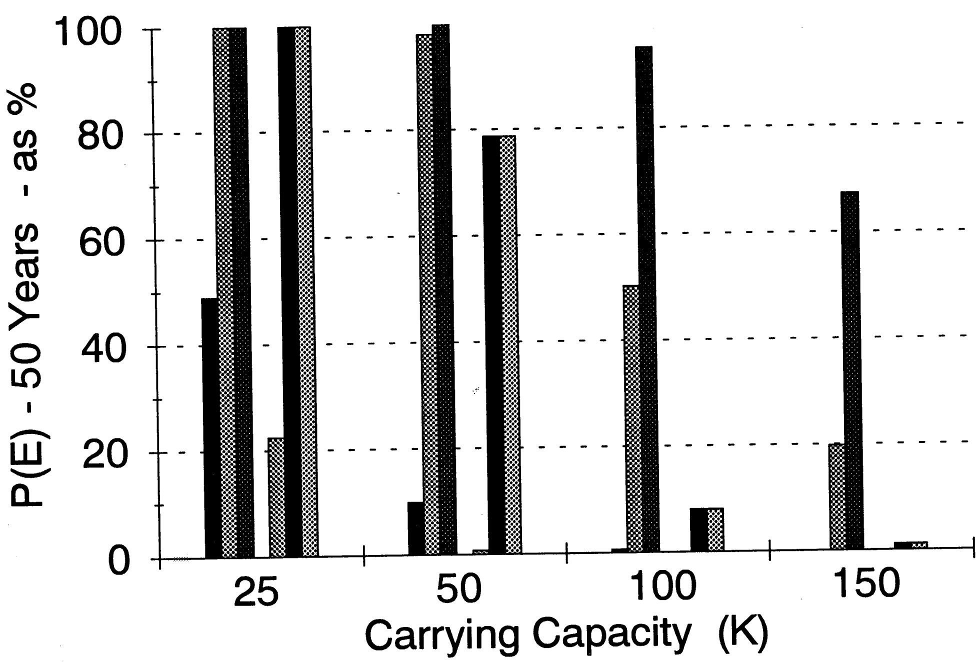


Table 4. For the Sumatran tiger in the base scenarios (files 18, 10, 34, and 26) with a mean litter size of 3 and with K=25, 50, 100, 150 but without the inclusion of inbreeding or catastrophes the deterministic values calculated for each scenario are the same.

Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression):

r = 0.086 lambda = 1.089 R0 = 1.830

Generation time for: females = 7.05 males = 6.77

Stable age distribution:

Age Class	Females	Males
0	0.154	0.154
1	0.092	0.092
2	0.072	0.072
3	0.040	0.046
4	0.033	0.030
5	0.027	0.022
6	0.022	0.016
7	0.018	0.012
8	0.015	0.009
9	0.013	0.006
10	0.010	0.005
11	0.009	0.003
12	0.007	0.003
13	0.006	0.002
14	0.005	0.001
15	0.004	0.001

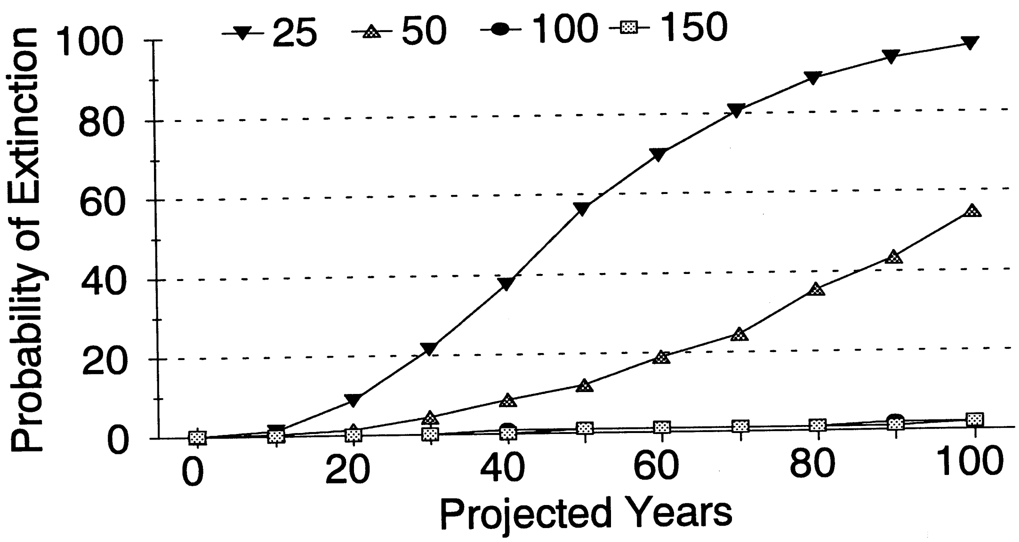
Ratio of adult (>= 4) males to adult (>= 3) females: 0.522

Stochastic Simulation Results

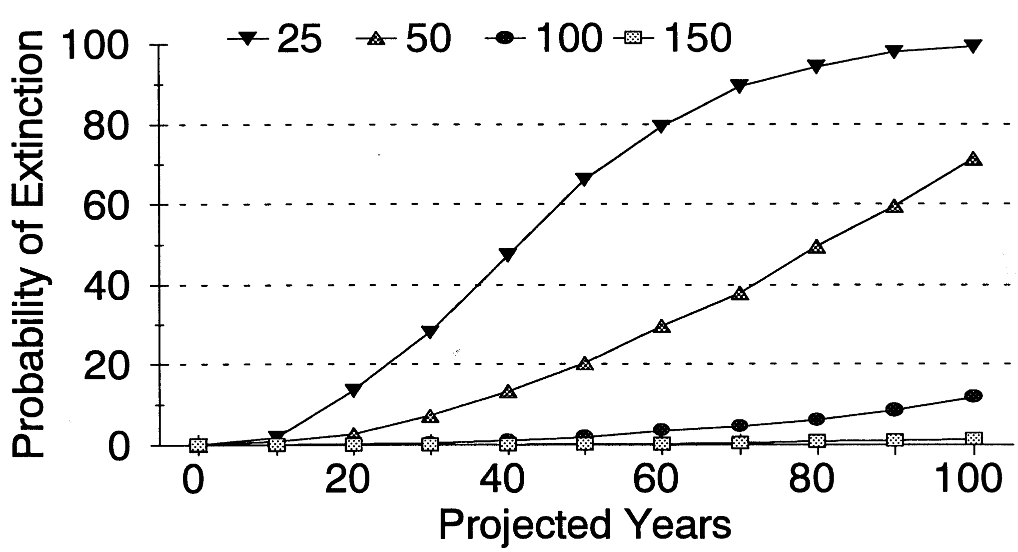
Litter Size: It is possible for a population to have a negative stochastic growth rate and a significant risk of extinction even though the deterministic growth rate, calculated from the Leslie matrix, is positive. This occurred many times in these stochastic simulation scenarios for the Sumatran tiger (Table 3). Although a positive deterministic growth rate (r) for the population was obtained for mean litter sizes of two or three cubs, the r value was decreased more than half in the scenarios with a mean litter size of two cubs. These comparisons might lead to the interpretation that if given enough habitat the Sumatran tiger populations should be able to rebound and grow to carrying capacity, if other factors leading to decline are controlled. However this interpretation fails to include normal environmental variability and the possible effects of population size, inbreeding, or occasional catastrophes, which are difficult to control in wild populations.

SUMATRAN TIGERS PHVA

Effect of K & Catastrophe F=10%

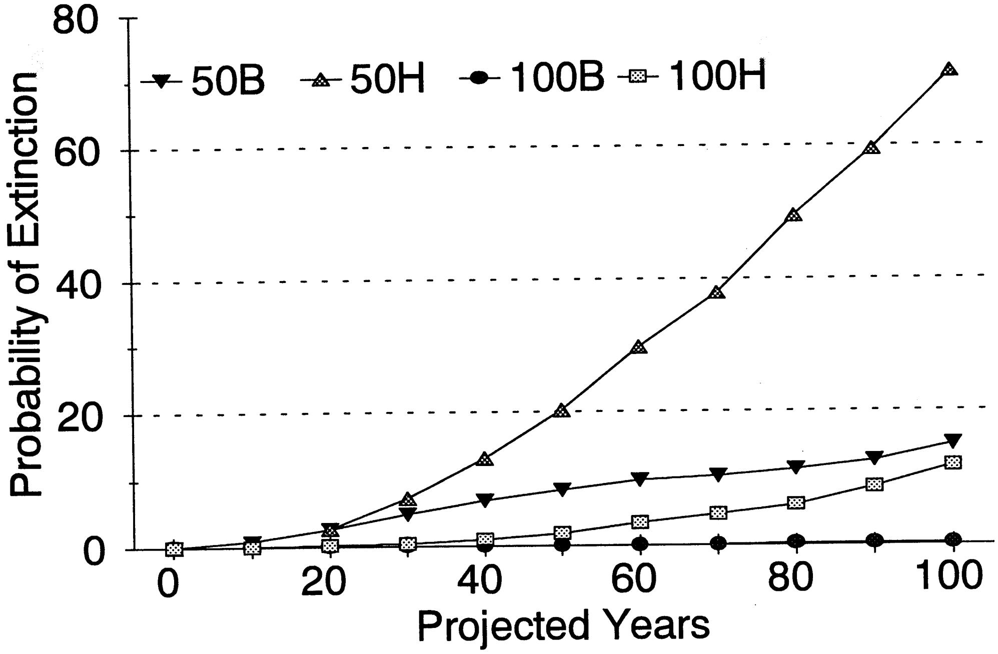


Effect of K & Catastrophe F=20%

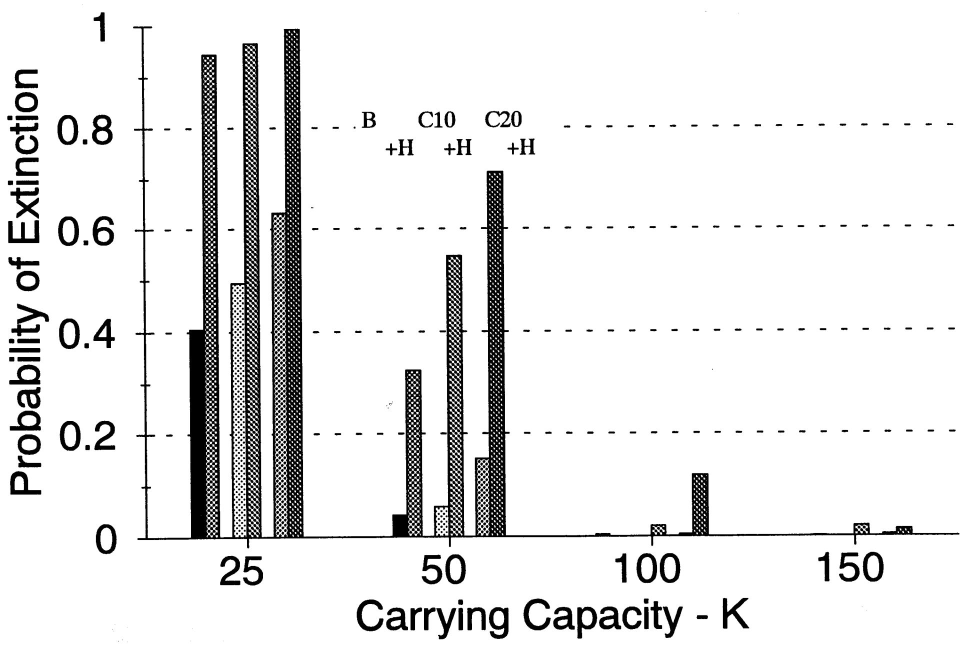


SUMATRAN TIGERS PHVA

Interaction of K=50 or 100, H, & C=20%



Interactions of K, H, & C



The viability of populations with mean litter sizes of 2, in these simulations, is not encouraging for population sizes less than 100 animals (Figures 1 - 4), even in the absence of removal losses and with no inbreeding depression effects. The probability of extinction (Pe) at 100 years was 75% for K=25 and 34% for K=50. The viability at higher population levels (K=100 or 150) was sustained only if there are no inbreeding depression or catastrophe effects - which is unlikely (Figures 1 & 4). The 100 year probability of extinction quickly rises from 2% to 16-46% depending upon the combination of threats. This high probability of extinction is a refection of the negative stochastic r values (Figure 3) which will inevitably lead to extinction. Thus it will be important to determine if a litter size of 2 is a persistent characteristic of any of the Sumatran tiger populations and to evaluate reasons for these small litters or whether they have better survival than comparable aged animals in other tiger populations. The addition of catastrophes or inbreeding accelerates the risk of extinction (Figure 1). Additional removals of adult animals further increases the risk of extinction (Figure 4) and assures the extinction of the smaller populations in less than 50 years.

<u>Carrying Capacity:</u> The base population with K=25 and no threats included (Table 3, file 018) has a 40% probability of extinction in 100 years and a mean time to first extinction of 53 years. This is despite positive deterministic and stochastic growth rate values. The surviving populations range in size from about 8 to 25 animals. A notable feature of this base scenario is the large 70% loss of genetic heterozygosity in the 14 generations. This amounts to a loss of about 5 per cent per generation. This rate of loss is about 10-fold greater than the suggested maximum rate of 0.5% per generation to minimize potential adverse effects of inbreeding. A similar 5% rate of loss in Florida panthers resulted in evidence for severe inbreeding depression in the wild population.

Increase in the carrying capacity to 50 produced a 10-fold reduction in Pe to 4.2% (Table 3). Another doubling of K to 100 yielded another 10-fold reduction in Pe to 0.4% (Figures 7 & 12). Surviving population sizes at 100 years in scenarios with K=50 or greater were near K.

<u>Catastrophes</u>: Catastrophe frequencies of 10% and 20% were tested (Figures 5 & 6 & 9 & 10). The severity of 0.9 on survival is similar to a loss of 10% of the population on the average of once in either 5 or 10 years. Populations of 100 or greater were able to sustain this rate of loss with populations near carrying capacity at 100 years.

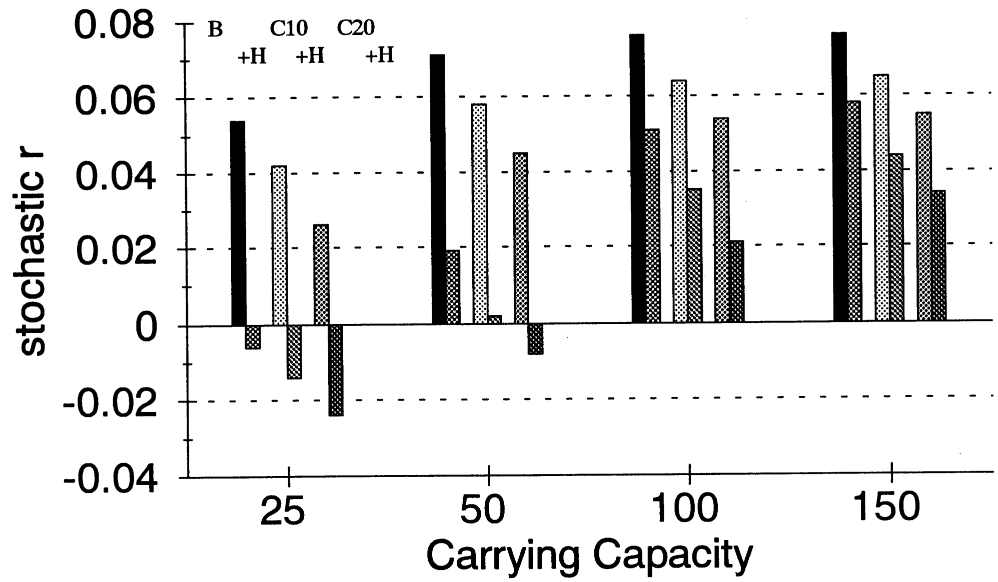
A similar picture emerged for annual removals of 2 or 4 animals from the different size populations (Figures 3 & 4). This would be comparable to the removal of 10 or 20 animals every 5 years and 20 or 40 animals every 10 years. At the longer time interval between the removals in the larger populations there is an opportunity for replacement and even breeding by the replaced animals between events to restore the population to carrying capacity. The removal of an absolute number of animals annually has, as expected, a much greater effect on the smaller populations.

Table 5. SUMATRAN TIGER - DEMOGRAPHY - EFFECTS OF REMOVALS

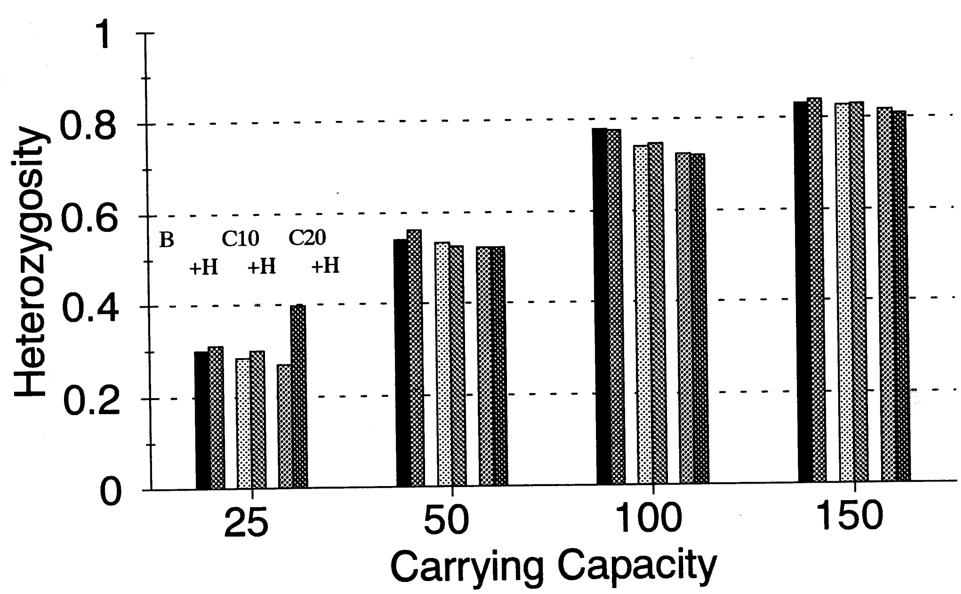
File				Results							
	Lit # Mean	K	Removals	Population Growth			100 Years				Te Yrs
				Deter r	Stochastic r	SD	Pe	N	SD	He	
No Harvests, No Catastrophe, No Inbreeding											
018	3	25	0	.086	.05	.27	.404	20	6	.298	53
020	2	25	0	.031	-.01	.26	.754	17	7	.298	45
010	3	50	0	.086	.07	.21	.042	44	9	.541	42
012	2	50	0	.031	.01	.21	.344	34	13	.514	54
034	3	100	0	.086	.08	.19	.004	90	13	.779	34
036	2	100	0	.031	.02	.17	.020	71	25	.744	72
026	3	150	0	.086	.08	.18	0	140	16	.830	-
028	2	150	0	.031	.02	.17	.028	110	35	.803	61
2 Adults Removed, No Catastrophe, No Inbreed											
	3	25	2	.086	-.21	.39	1	0			
	2	25	2	.031	-.25	.36	1	0			
	3	50	2	.086	-.05	.30	.974	29	12	.597	
	2	50	2	.031	-.12	.29	1	0			
	3	100	2	.086	.04	.20	.204	82	21	.769	
	2	100	2	.031	-.04	.23	.865	54	28	.754	
	3	150	2	.086	.06	.18	.026	133	23	.851	
	2	150	2	.031	-.02	.20	.585	85	43	.842	
4 Adults Removed, No Catastrophe, No Inbreed											
	3	25	4	.086	-.44	.47	1	0			
	2	25	4	.031	-.47	.45	1	0			
	3	50	4	.086	-.20	.38	1	0			
	2	50	4	.031	-.26	.38	1	0			
	3	100	4	.086	-.03	.27	.872	69	27	.747	
	2	100	4	.031	-.13	.30	1	0			
	3	150	4	.086	-.03	.21	.296	122	33	.836	
	2	150	4	.031	-.07	.26	.957	88	45	.827	

SUMATRAN TIGER

Interactions of H, C, & K

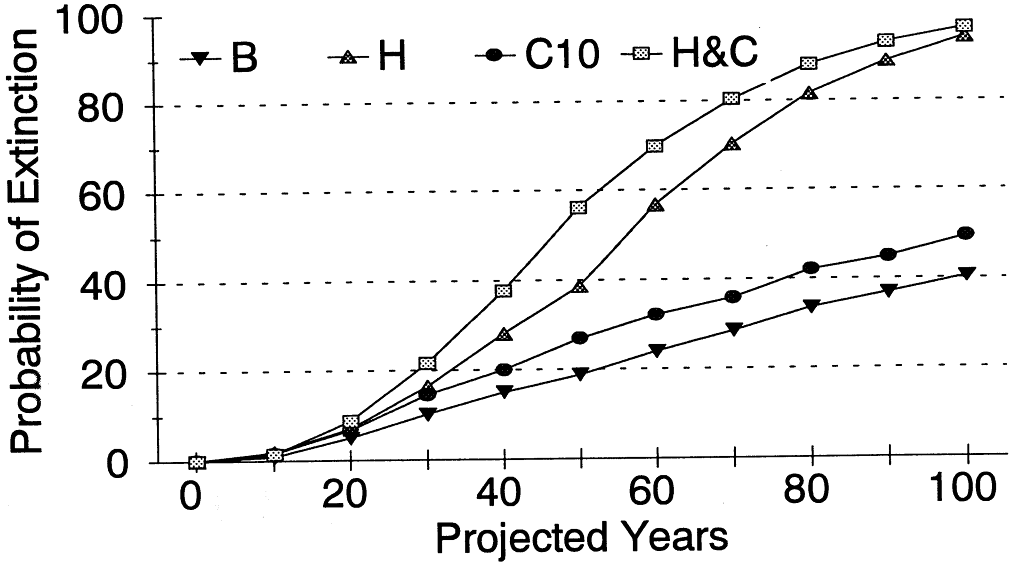


Interactions of K, H, & C

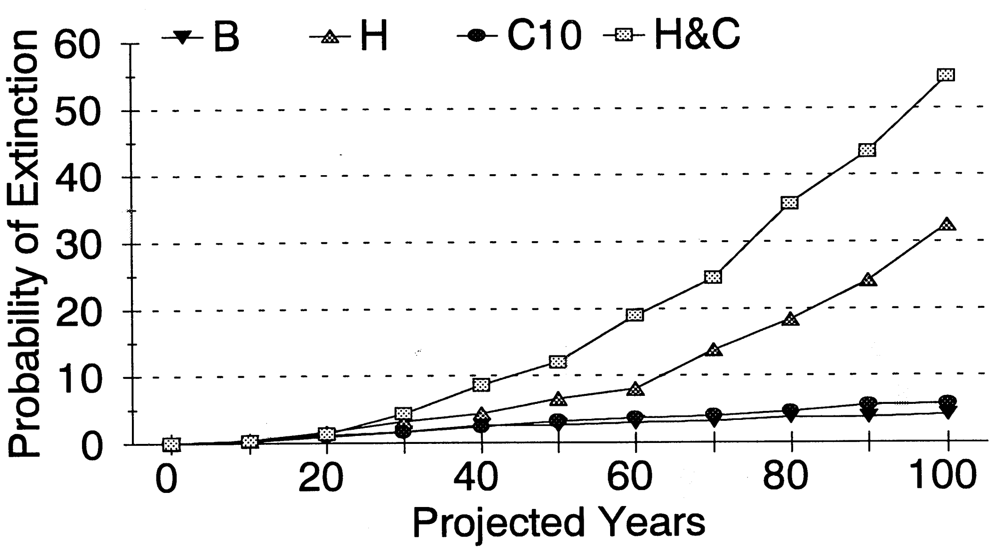


SUMATRAN TIGERS PHVA

Interaction of K=25, H, & C=10%



Interaction of K=50, H, & C=10%



Proportion Males in Breeding Pool: An increase of the proportion of males in the breeding pool from 50 to 100% in populations with K=25 had no effect on the deterministic or the stochastic r values (Table 3). The Pe was consistently but very modestly reduced in the populations with a mean litter size of 3. The loss of genetic heterozygosity was also reduced but the rate was still greater than 4% per generation. Thus the basic picture of the extinction risk faced by small populations was not altered.

Inbreeding Depression: Another significant effect of K or population size was seen on proportion of initial heterozygosity retained in the population. At population sizes of 100 and 150 the rate of decline was about 1% per generation whereas at K=50 the loss was about 3% per generation. Addition of inbreeding depression accelerated by 2 to 10-fold the rate of population loss for populations at K=25 or 50. These effects were more significant than the addition of a catastrophe at 10% frequency. If inbreeding depression is significant for Sumatran tigers, it will be necessary to include genetic management in possible interventions for populations of 100 or fewer animals.

CONSERVATION MANAGEMENT RECOMMENDATIONS

1. The highest priority for the conservation management of wild Sumatran tigers is to secure and protect tiger populations (and their habitat) of 100 animals or more.

2. A second priority is to develop conservation management goals and intervention strategies for each of the remaining wild Sumatran tiger populations. This may include demographic and genetic support for populations of less than 100 animals. Special consideration needs to be given to periodic genetic supplementation to populations of 50 or fewer animals.

3. A third priority is to control animal removals, either officially or illegally, from individual populations for whatever purpose such that less than 10% of the population is lost in any five-year period.

4. A fourth priority is to initiate necessary field research and long-term monitoring to establish the critical life history parameters of wild Sumatran tiger populations. Of particular significance is to determine mean litter size. Evaluation of wild-caught tigers brought into the captive population through official removals should be evaluated for indicators of inbreeding depression.

SUMMARY AND INTERPRETATION OF SIMULATION RESULTS FOR EACH PROTECTED AREA

Definitions

Estimated population sizes are for animals 1 year and older. About half this number will be breeding age adults. The estimate of removed tigers includes animals lost to poaching as well as problem animals removed. The estimates of extinction risk are for 100 years with 50 year estimates included in Table 5. In all instances the probability of extinction is high with removals if the mean litter size is 2 cubs. The risk estimates quoted are for litter sizes of 3 with no inbreeding depression but with either 0% (Table 5) or a 10% (Table 3) probability of a catastrophe event which reduces survival by 10% in the year of occurrence. We believe that these are conservative estimates because the risks would be greater if inbreeding depression is included in these small population simulation scenarios.

Gunung Leuser National Park

Total area (ha):	≈900,000
Available habitat:	40% (360,000 ha)
Estimated population size:	110 tigers (2000 ha per tiger)
Number tigers removed per year:	2-4

Comments: Risk of extinction is 20% (100 years) given two tigers removed per year (Te mean = 59 years; 80% H_e retained); probability of extinction rises to 87% with four tigers removed per year (Te mean = 45 years; 75% H_e retained).

Kerinci-Seblat National Park

Total area (ha):	≈1,500,000
Available habitat:	40% (600,000 ha)
Estimated population size:	76 tigers (7,895 ha per tiger)
Number tigers removed per year:	6

Comments: Even if the tiger population is assumed to be one population (no fragmentation, which is unlikely), there is essentially a 100% probability of extinction within 50 years (mean=17 years to extinction). Poaching/removal has an overwhelming effect on the survival of the population.

Barisan Selatan National Park

Total area (ha):	≈356,800
Available habitat:	79% (281,872 ha)
Estimated population size:	68 tigers (4,145 ha per tiger)
Number tigers removed per year:	1

Comments: This population, with only one tiger removed per year, has less than 1% probability of extinction in 100 years, with 84% H_e retained. However, this simulation did not include catastrophes or inbreeding effects, which may increase the Pe to 10% in 100 years in this size population.

Berbak National Park

Total area (ha):	≈162,700
Available habitat:	70% (113,890 ha)
Estimated population size:	50 tigers (2,278 ha per tiger)
Number tigers removed per year:	2

Comments: Highly likely to go extinct (Pe = 97%) within 100 years (mean=31 years to extinction). Although the estimated population is smaller than that for Kerinci, the Berbak population does slightly better in the simulations because of the lower estimated level of removed/poached individuals. If the model starts with an initial population of 150 tigers (50 adults in park, 50 adults in the proposed surrounding HL area, 50 immatures), then there would be a 1% probability of extinction, with 85% H_e retained.

Way Kambas National Park

Total area (ha):	≈130,000
Available habitat:	75% (97,500 ha)
Estimated population size:	20 tigers (4,875 ha per tiger)
No. tigers removed per year:	0

Comments: Probability of extinction is 40-70% (depending upon mean litter size) within 100 years (mean=48 years to extinction). Even though no animals are being removed from the population, random events in small populations greatly increase the risk of extinction. Inclusion of inbreeding effects in the simulation model increases the risk of extinction to 94+% or the inclusion of a catastrophe at 10 % probability of occurrence increases the PE to 49%. Both factors are real risks. If the model starts with 40 tigers (additional adults plus some cubs), then there is only 2% probability of extinction, but the population becomes very inbred (only 50% H_e retained). By adding one female to the population every year, the probability of survival remains the same, but the population retains much more heterozygosity, 88% H_e .

Kerumutan Game Reserve

Total area (ha):	≈120,000
Available habitat:	65% (78,000 ha)
Estimated population size:	30 tigers (2,600 ha per tiger)
Number tigers removed per year:	2

Comments: 100% probability of extinction in 50 years with a mean time to first extinction = 15 years.

Rimbang Game Reserve

Total area (ha):	≈136,000
Available habitat:	90% (122,400 ha)
Estimated population size:	42 tigers (2,914 ha per tiger)
No. tigers removed per year:	2

Comments: There is a projected 100% probability of extinction (Te = 25 years). The populations at Kerumutan and Rumbang Game Reserves are very vulnerable to poaching effects (without poaching, results should be similar to Way Kambas with initial population size of 40); therefore, it is important to control poaching.■

Table 6. Input file for a base scenario with an average litter size of 3, K=50, starting population size of 25, no catastrophes, and no inbreeding.

TIGER.010	***Output Filename***
N	***Graphing Files?***
500	***Simulations***
100	***Years***
10	***Reporting Interval***
1	***Populations***
N	***Inbreeding Depression?***
N	***EV correlation?***
2	***Types Of Catastrophes***
P	***Monogamous Or Polygynous***
3	***Female Breeding Age***
4	***Male Breeding Age***
15	***Maximum Age***
0.500000	***Sex Ratio***
5	***Maximum Litter Size***
N	***Density Dependent Breeding?***
50.000000	***Population 1: Percent Litter Size 0***
0.000000	***Population 1: Percent Litter Size 1***
12.000000	***Population 1: Percent Litter Size 2***
29.000000	***Population 1: Percent Litter Size 3***
8.000000	***Population 1: Percent Litter Size 4***
1.000000	***Population 1: Percent Litter Size 5***
12.500000	***EV--Reproduction***
35.000000	***Female Mortality At Age 0***
15.083103	***EV--FemaleMortality***
15.000000	***Female Mortality At Age 1***
10.000000	***EV--FemaleMortality***
40.000000	***Female Mortality At Age 2***
14.770979	***EV--FemaleMortality***
10.000000	***Adult Female Mortality***
5.000000	***EV--AdultFemaleMortality***
35.000000	***Male Mortality At Age 0***
15.083103	***EV--MaleMortality***
15.000000	***Male Mortality At Age 1***
10.000000	***EV--MaleMortality***
30.000000	***Male Mortality At Age 2***
11.114379	***EV--MaleMortality***
30.000000	***Male Mortality At Age 3***
15.000000	***EV--MaleMortality***
20.000000	***Adult Male Mortality***
8.000000	***EV--AdultMaleMortality***
2.000000	***Probability Of Catastrophe 1***
1.000000	***Severity--Reproduction***
1.000000	***Severity--Survival***
10.000000	***Probability Of Catastrophe 2***
1.000000	***Severity--Reproduction***
1.000000	***Severity--Survival***
N	***All Males Breeders?***
Y	***Answer--A--Known?***
50.000000	***Percent Males In Breeding Pool***
Y	***Start At Stable Age Distribution?***
25	***Initial Population Size***
50	***K***
0.000000	***EV--K***
N	***Trend In K?***
N	***Harvest?***
N	***Supplement?***

Table 7. VORTEX output file for the input file listed in Table 1. This is a base scenario with litter size = 3 and K = 50 with no inbreeding, catastrophes, or harvests included.

VORTEX -- simulation of genetic and demographic stochasticity

TIGER.010
Sun Jan 23 16:09:09 1994

1 population(s) simulated for 100 years, 500 iterations
No inbreeding depression
First age of reproduction for females: 3 for males: 4
Age of senescence (death): 15
Sex ratio at birth (proportion males): 0.50000

Population 1:
Polygynous mating;
50.00 percent of adult males in the breeding pool.

Reproduction is assumed to be density independent.
50.00 (EV = 12.50 SD) percent of adult females produce litters of size 0
0.00 percent of adult females produce litters of size 1
12.00 percent of adult females produce litters of size 2
29.00 percent of adult females produce litters of size 3
8.00 percent of adult females produce litters of size 4
1.00 percent of adult females produce litters of size 5

35.00 (EV = 15.08 SD) percent mortality of females between ages 0 and 1
15.00 (EV = 9.90 SD) percent mortality of females between ages 1 and 2
40.00 (EV = 14.77 SD) percent mortality of females between ages 2 and 3
10.00 (EV = 5.00 SD) percent annual mortality of adult females (3<=age<=15)
35.00 (EV = 15.08 SD) percent mortality of males between ages 0 and 1
15.00 (EV = 9.90 SD) percent mortality of males between ages 1 and 2
30.00 (EV = 11.11 SD) percent mortality of males between ages 2 and 3
30.00 (EV = 15.28 SD) percent mortality of males between ages 3 and 4
20.00 (EV = 8.00 SD) percent annual mortality of adult males (4<=age<=15)
EVs may have been adjusted to closest values
possible for binomial distribution.
EV in mortality will be correlated among age-sex classes
but independent from EV in reproduction.

Frequency of type 1 catastrophes: 2.000 percent
with 1.000 multiplicative effect on reproduction
and 1.000 multiplicative effect on survival

Frequency of type 2 catastrophes: 10.000 percent
with 1.000 multiplicative effect on reproduction
and 1.000 multiplicative effect on survival

Initial size of Population 1:
(set to reflect stable age distribution)

Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total	
3	3	2	1	0	1	0	1	0	0	0	0	0	0	1	12	Males
3	3	1	2	1	0	1	1	0	0	1	0	0	0	0	13	Females

Carrying capacity = 50 (EV = 0.00 SD)

Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression):
r = 0.086 lambda = 1.089 R0 = 1.830
Generation time for: females = 7.05 males = 6.77

Stable age distribution:

Age class	females	males
0	0.154	0.154
1	0.092	0.092
2	0.072	0.072
3	0.040	0.046
4	0.033	0.030
5	0.027	0.022
6	0.022	0.016
7	0.018	0.012
8	0.015	0.009
9	0.013	0.006
10	0.010	0.005
11	0.009	0.003
12	0.007	0.003
13	0.006	0.002
14	0.005	0.001
15	0.004	0.001

Ratio of adult (>= 4) males to adult (>= 3) females: 0.522

Population1

Year 10
N[Extinct] = 2, P[E] = 0.004
N[Surviving] = 498, P[S] = 0.996
Population size = 40.32 (0.49 SE, 10.98 SD)
Expected heterozygosity = 0.912 (0.001 SE, 0.029 SD)
Observed heterozygosity = 0.968 (0.002 SE, 0.036 SD)
Number of extant alleles = 19.23 (0.20 SE, 4.35 SD)

Year 20
N[Extinct] = 6, P[E] = 0.012
N[Surviving] = 494, P[S] = 0.988
Population size = 43.06 (0.45 SE, 9.99 SD)
Expected heterozygosity = 0.861 (0.002 SE, 0.047 SD)
Observed heterozygosity = 0.906 (0.003 SE, 0.061 SD)
Number of extant alleles = 12.73 (0.12 SE, 2.73 SD)

Year 30
N[Extinct] = 8, P[E] = 0.016
N[Surviving] = 492, P[S] = 0.984
Population size = 42.99 (0.43 SE, 9.45 SD)
Expected heterozygosity = 0.815 (0.003 SE, 0.062 SD)
Observed heterozygosity = 0.858 (0.004 SE, 0.083 SD)
Number of extant alleles = 9.64 (0.10 SE, 2.15 SD)

Year 40
N[Extinct] = 13, P[E] = 0.026
N[Surviving] = 487, P[S] = 0.974
Population size = 43.17 (0.40 SE, 8.85 SD)
Expected heterozygosity = 0.770 (0.003 SE, 0.074 SD)
Observed heterozygosity = 0.812 (0.004 SE, 0.096 SD)
Number of extant alleles = 7.65 (0.08 SE, 1.78 SD)

Year 50
N[Extinct] = 13, P[E] = 0.026
N[Surviving] = 487, P[S] = 0.974
Population size = 43.48 (0.40 SE, 8.90 SD)
Expected heterozygosity = 0.730 (0.004 SE, 0.094 SD)
Observed heterozygosity = 0.772 (0.005 SE, 0.118 SD)
Number of extant alleles = 6.40 (0.07 SE, 1.51 SD)

Year 60
N[Extinct] = 15, P[E] = 0.030
N[Surviving] = 485, P[S] = 0.970
Population size = 43.77 (0.39 SE, 8.54 SD)
Expected heterozygosity = 0.693 (0.005 SE, 0.107 SD)
Observed heterozygosity = 0.727 (0.006 SE, 0.130 SD)
Number of extant alleles = 5.52 (0.06 SE, 1.36 SD)

Year 70
N[Extinct] = 16, P[E] = 0.032
N[Surviving] = 484, P[S] = 0.968
Population size = 43.49 (0.40 SE, 8.75 SD)
Expected heterozygosity = 0.648 (0.006 SE, 0.134 SD)
Observed heterozygosity = 0.684 (0.007 SE, 0.154 SD)
Number of extant alleles = 4.86 (0.06 SE, 1.29 SD)

Year 80
N[Extinct] = 19, P[E] = 0.038
N[Surviving] = 481, P[S] = 0.962
Population size = 43.60 (0.38 SE, 8.32 SD)
Expected heterozygosity = 0.614 (0.006 SE, 0.142 SD)
Observed heterozygosity = 0.647 (0.007 SE, 0.162 SD)
Number of extant alleles = 4.37 (0.06 SE, 1.22 SD)

Year 90
N[Extinct] = 19, P[E] = 0.038
N[Surviving] = 481, P[S] = 0.962
Population size = 44.19 (0.40 SE, 8.83 SD)
Expected heterozygosity = 0.579 (0.007 SE, 0.160 SD)
Observed heterozygosity = 0.612 (0.008 SE, 0.181 SD)
Number of extant alleles = 3.95 (0.05 SE, 1.13 SD)

Year 100
N[Extinct] = 21, P[E] = 0.042
N[Surviving] = 479, P[S] = 0.958
Population size = 43.73 (0.39 SE, 8.52 SD)
Expected heterozygosity = 0.541 (0.008 SE, 0.171 SD)
Observed heterozygosity = 0.568 (0.009 SE, 0.192 SD)
Number of extant alleles = 3.65 (0.05 SE, 1.09 SD)

In 500 simulations of Population1 for 100 years:
21 went extinct and 479 survived.

This gives a probability of extinction of 0.0420 (0.0090 SE),
or a probability of success of 0.9580 (0.0090 SE).

21 simulations went extinct at least once.
Of those going extinct,
mean time to first extinction was 42.19 years (6.29 SE, 28.82 SD).

No recolonizations.

Mean final population for successful cases was 43.73 (0.39 SE, 8.52 SD)

Age 1	2	3	Adults	Total	
5.85	4.44	2.96	6.97	20.22	Males
5.83	4.60		13.08	23.51	Females

Without harvest/supplementation, prior to carrying capacity truncation,
mean growth rate (r) was 0.0709 (0.0009 SE, 0.2087 SD)

Final expected heterozygosity was 0.5406 (0.0078 SE, 0.1712 SD)
Final observed heterozygosity was 0.5676 (0.0088 SE, 0.1924 SD)
Final number of alleles was 3.65 (0.05 SE, 1.09 SD)
****

TIGER POPULATION MANAGEMENT

Robert Wiese, David Wildt, Ann Byers, and Leslie Johnston

Tiger populations in Sumatra are fragmented and isolated into 5-12 small reserves that have varying degrees of migration between them. In the case of the five distinct National Parks, no natural migration is possible. These small isolated populations are at greater risk from random and deterministic processes (e.g., skewed sex ratio, failure to locate mates, disease, genetic drift, inbreeding, etc.) that are effectively less in large populations. Therefore, these populations will require intensive management if the Sumatran tiger is to survive for a considerable amount of time in the future.

From a conservation management standpoint the primary goal should be to reduce the number of tigers removed to the lowest level possible. This should primarily involve the elimination of poaching wherever possible. In addition, alternatives to the removal of problem animals should be explored to determine if it may be possible to allow some problem animals to remain in the population. Of course, some problem animals will always need to be removed.

Another priority for management should be the retention of the largest tracts of habitat possible and to avoid fragmentation of the designated tiger parks and reserves whenever possible.

Finally, the third priority for the effective management of the Sumatran tiger should be increased investigation into the biology of this subspecies. Specifically, it will be important to quantify the tigers' fecundity and mortality rates on Sumatra.

Many of the reserves and some of the national parks or their fragments are too small to retain a viable population of tigers over the long-term. Reserves that cannot support a population of more than 50 tigers with no removal, or reserves that possess a larger population but experience removal pressure will require continuing intensive management assistance. This assistance will take the form of either augmentation of an existing population with additional tigers, genetic management, or the reestablishment of populations that have become extirpated. Passive management or no action will lead to a gradual extinction of the Sumatran tiger through attrition of the existing populations through time.

Augmentation will be required in populations that have reduced heterozygosity and begin to show inbreeding depression and/or in populations which experience severe demographic perturbations such as highly skewed sex ratios. Although augmentation or establishment are not issues requiring immediate attention, investigation into their feasibility should begin now, before the situation becomes critical. The following section discusses several scenarios which may be considered by the managers for population augmentation.

SCENARIOS FOR THE GENETIC MANAGEMENT OF ISOLATED POPULATIONS

I. No Action.

As stated above, this management decision will lead to a slow decline in the number of extant tiger populations on Sumatra with the eventual extinction of the subspecies in all but the very largest parks. Even the largest population in Gunung Leuser may be at risk in the future if no action is selected.

II. Translocation of Free-Living Individuals Between or Among National Parks.

In this scenario, animals are moved between or among geographic locations depending upon genetic or demographic need. This would require the capture and physical translocation of living animals. The decision process would include:

a. the site of need for a new individual;
b. the site from which the animal to be translocated is to be captured; and
c. the specific animal to be moved (including sex and age class).

Current knowledge, based upon the assumption that reproductively effective males maintain individual territories, suggests that it would be best to move adult or subadult females rather than similarly aged males. One advantage of this strategy is that the translocated animals are already habituated to the wild, and therefore, have a higher likelihood of surviving over captive bred counterparts. Hands on access to individual animals will increase the database exponentially on the health status of the wild population.

The number of tigers that will have to be transferred among populations to maintain genetic diversity will depend on the amount and type of genetic diversity one wishes to retain and the size of the recipient population. The smaller the population and the more genetic diversity desired, the more migrants per generation required. The specific number of individuals, therefore, will have to determined at the time of plan implementation. This may also be an outlet for problem animals such that they are not removed from the entire metapopulation.

The disadvantages are: 1) the risk of moving living individuals; 2) the possibility of the individuals either moving back to original capture area or becoming transients; and 3) the potential disruption of the existing social structure at the transfer site. Also of concern is the possibility of transmitting as yet unknown pathogens or diseases from one population to another. This scenario will be challenging when the park size is small, because of the difficulty of balancing genetic needs, absolute animal numbers and the total carrying capacity of the habitat.

III. Assisted Reproduction of Wild-Caught Adult Females

In this strategy, adult, free-living females are captured, held in captivity for a brief period to be artificially inseminated, and then are released back into their home range. Semen is collected from wild or captive male tigers and used to inseminate wild-caught females. Following AI, the female is released into her home range. The primary advantage of this approach include avoiding the need to transfer living individuals between populations. Again, having direct hands on access to wild animals will help establish a database on the medical status of the wild population. The disadvantages are that females must undergo the stress of short-term capture and anesthesia. It also will be difficult, if not impossible, to determine if a female scheduled for capture is potentially pregnant. There are the remote possibilities that: 1) a captured female may lose her territory; or 2) infanticide by the resident male after cubbing. Finally, although AI has been used to produce offspring in the tiger, the technology is not highly efficient at present; additional and parallel studies are required to further refine AI techniques in this species. Also, this scenario would not be adequate to alter demographic sex-ratio instabilities, as the sex of the offspring cannot be selected.

IV. Translocation (Release) of Captive Bred Individuals into Wild Populations

In this strategy, the primary source of new genetic material originates from the Indonesian Captive Breeding Program already in existence and a participant in the Tiger Global Animal Survival Plan. Founders used in this program come from two sources: 1) wild-caught specifically for captive breeding; or 2) problem animals (e.g., transients outside the park boundaries, human or livestock killers or injured/rehabilitated individuals). Artificial insemination can be used within the captive breeding program, and *in vitro* fertilization (IVF) can be considered once laboratory technology is improved. Pregnant females are allowed to deliver offspring in the captive facilities and then the young are released into the wild. Major decisions will include determining the sex and age class of the captive-bred young for release. Given assumptions described in Scenario III, it is expected that the best captive-bred candidates for reintroduction are subadult or adult females.

The major advantage is that a captive breeding program and a state-of-the-art facility already exist in Indonesia. Other advantages are: 1) a high degree of control over the production of genetically valuable tigers; 2) reinforcement of the captive population which serves as insurance for the free-living population; 3) sex of the released animals can be controlled to adjust the sex ratio of the wild population; and 4) clinical history of the animals will be known which can reduce the chance of introducing dangerous pathogens into the wild.

The primary disadvantage is the lack of information on survivorship of captive-bred felids released into native habitats. Experience with other carnivores has shown that a period of training is required for potential release individuals. A detailed set of studies will need to be conducted to determine the minimum training requirements and conditioning of individuals in preparation for release. Other disadvantages are that individuals raised in captivity are habituated to people, and the expenses of a soft-release program.

V. Cross-Fostering of Captive-Born Cubs to Free-Living Resident Females

In this strategy, the primary source of new genetic material originates from replacing newborn wild-born cubs with cubs produced by natural breeding or AI in the captive breeding program. Wild-born cubs will then be cross-fostered to the captive female and become part of the captive breeding program. The advantages of this strategy include the increased chances of survivorship of captive-born cubs in the wild because training will be provided by the free-living foster female. Disadvantages are that intensive monitoring is required of individual females before and after parturition, accurate timing of pregnancy of captive females is required, and the risks to the cubs during the cross-fostering process.

GENETIC RESOURCE BANKING

A major component to genetic metapopulation management of the Sumatran tiger can be the systematic collection, storage and use of genetic material, primarily spermatozoa at present [*editors' note: This recommendation was incorporated into the PKBSI Sumatran Tiger Captive Breeding Masterplan*]. It is recommended that the genetic metapopulation plan for the Sumatran tiger implement the development of a systematic Genetic Resource Bank. The details of a strategy for formulating such a repository are available and organization of the program can be assisted by the IUCN's Captive Breeding Specialist Group.■

SUMATRAN TIGER

POPULATION AND HABITAT

VIABILITY ANALYSIS WORKSHOP

Sumatran tiger (photo courtesy of Taman Safari Indonesia).

SECTION 3

PHPA SUMATRAN TIGER ACTION PLAN

PHPA Sumatran Tiger Action Plan

Komar Soemarna, Widodo Ramono, Effendy Sumardja, and Workshop Participants

Short Term Goals:

1. Improve the ability to acquire and manage data for use in GIS system through daily continual monitoring programs.

2. Each Park Chief assign 1-3 people in office to train in use of GIS.

3. Work with tiger researchers (ecology, behavior) in field work and analysis, beginning with a pilot project in Way Kambas NP and later extension into other protected areas.

4. Continue developing mapping system that will use a standardized data format.
   a) lowest level knowledge on data compilation
   b) network on information
   c) provide GIS map for areas outside of National Parks

5. Compile data on tiger-human interactions and evaluate appropriate non-monetary compensation.

6. Establish a Tiger Desk Officer for tiger issues.

7. Integrate a tiger component into the current anti-poaching program wherever tigers occur.

8. Evaluate extending boundaries of protected areas to include larger areas of tiger habitat or to connect tiger habitats (e.g., Berbak NP).

All Kepala (Chiefs of National Parks) as well as all Chief-Balai and Sub-Balai are responsible for short term Goals 1, 2 and 4-8. CBSG Tiger GASP is responsible for Goal 3 and assistance with Goal 4.

See next page for Long-Term Goals.

Long Term Goals:

1. Develop an accurate (standardized) mapping system using GIS to establish the distribution of tigers in Sumatra.

2. Develop a standardized reporting system to report tiger observations from the park guards to the Sub-Balai to the Balai to the Chiefs (Kepala) of the National Parks to the Jakarta PHPA Office.

3. Initiate the necessary field research (e.g., establish home range sizes) in order to establish tiger density in various habitats and protected areas.

4. Develop a strong communication network between the designated Tiger Desk Officer, PHPA and other agencies to foster cooperation and the sharing of information regarding tiger conservation.

5. Integrate *in situ* (protected areas) and *ex situ* (captive breeding) tiger programs in Indonesia, forming a collaboration between tiger conservation management programs.

6. Analyze land use practices in all tiger habitat, including those areas outside of protected areas, and use these data to suggest possible viable population management strategies, including extending protection to additional tiger habitat areas.

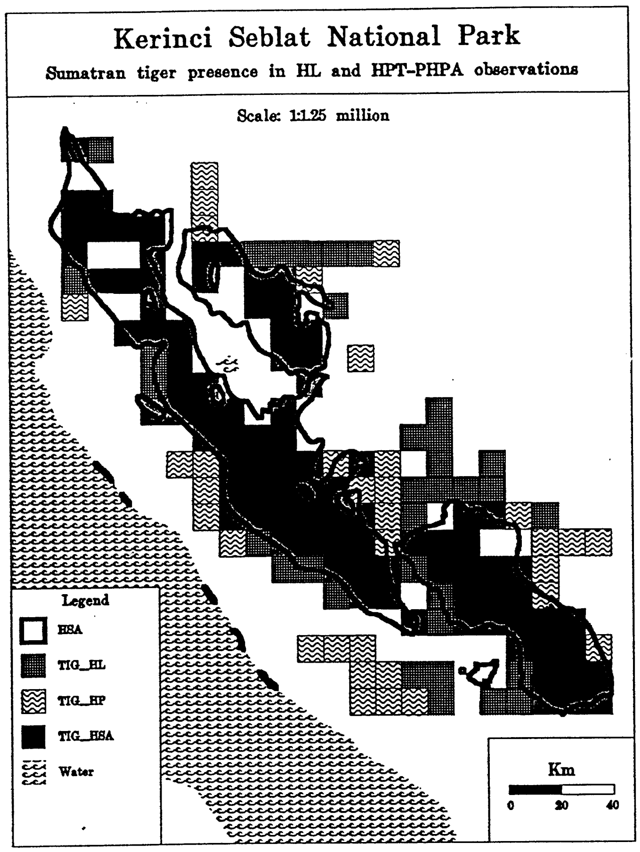
7. Incorporate tiger conservation information into broader conservation education programs in Indonesia.

8. Schedule another Sumatran tiger workshop in two to three years to analyze progress toward goals and evaluate more accurately the status of the tiger populations on Sumatra. At that workshop, better information should be available on tiger distribution, density, and the reasons for and rate of tiger loss. This will allow the drafting of an *Indonesian Conservation Strategy for the Sumatran Tiger.*

SUMATRAN TIGER

POPULATION AND HABITAT

VIABILITY ANALYSIS WORKSHOP



GIS analysis of Kerinci Seblat National Park, central Sumatra.

SECTION 4

TIGER FOLKLORE IN KERINCI, WEST SUMATRA

THE TIGER BY THE TAIL:
On tigers, ancestors and nature spirits in Kerinci

Jet Bakels, Leiden University, Centre of Non-Western Studies, the Netherlands

INTRODUCTION

In this paper I will focus on the meaning of the tiger for the Kerinci people and the role the big cat plays in the daily life of the villagers. Attention will be paid to the traditional rules of behavior that shape human conduct towards this animal. People sharing an ecological niche with the tiger (in the case of Kerinci it is the gardens in the forest where man and tiger can walk into each other) have developed a complex set of ideas about their mighty neighbor. How to avoid the tiger? How to find him? How to befriend him - and how to kill him? The answers to these questions are rooted in the local worldview. Therefore I shall pay attention to Kerinci conceptions of the forest and its inhabitants, 'real' (*nyata*) and 'invisible' (*gaib*). It should be stressed that I will talk about the 'cultural' tiger - a cultural construct - rather than the biological one. Thus I hope to offer a better insight into the way the Kerinci people perceive the tiger. To effectively protect the tiger in a certain region it is indispensable to work in cooperation with the local people. By giving an insight into Kerinci tiger-lore I hope to facilitate this cooperation.

METHODS

The data presented in this paper were collected during a five-month research period in Kerinci Seblat National Park (during November 1991 - May 1992). Most of the time I was a guest in the village of Keluru, situated on the southern border of Lake Kerinci. Several trips however were made to other villages such as Muak, Pulau Tengah, Jujun, Sungai Penuh and Siulak. Information was sought through extensive and repeated interviews with the villagers, especially *adat*-leaders, traditional (male and female) doctors (*dukun*) and hunters.

This fieldwork was carried out as part of a four-year Ph.D. project, focusing on the meaning and role of the tiger and the crocodile in several Indonesian societies. Within the scope of this research I also visited the Minangkabau, the Mentawaians, the Nias- and the Kubu-people.

NAMING THE TIGER

Throughout Indonesia the usual word for tiger is *macan*, derived from Sanskrit or *harimau*, a Malay word. *Macan* and *harimau* can refer to the tiger (*Panthera tigris*), but also to the clouded leopard (*Neofelis nebulosa*) or the leopard (*Panthera pardus*). Only when there is need to specify between the leopard and the tiger, the tiger is called the 'striped' tiger (*harimau/macan loreng*), the leopard the 'black' or 'spotted' tiger (*harimau/macan -kumbang, -dahan or -tutul).* In Kerinci, people can also refer to smaller cats as 'tigers.' Names I have heard include the *harimau akar* and the *harimau kijang*, both said to be small, spotted felines. For biologists working in the region it is important to be aware of this overlap in the use of the term '*harimau*.'

Once outside the village, in the gardens or the forest, people wouldn't dream of calling the big cat by these names. In the jungle the tiger is the oldest inhabitant; he lived in the forest long before humans came. Now that his domain is entered, it would be impolite to address him directly - as it would be impolite (*kasar*) to address an older person directly by his or her name. Therefore he is called by more respectful names such as 'grandfather-/grandmother-in-the-forest' or 'old-man-of-the-forest' (*nenek/orang tua di rimba*). Also the terms 'general' (*hulu balang*), king-of-the-forest (*raja hutan*) and 'he-who-guards-the-forest' (*penghuni hutan*) are often used.

KERINCI TIGERS

One only has to read travel accounts of the last century to realize the profound influence of tigers on village life in those days. It is therefore not surprising the tiger played an important role in the worldview of the Indonesian peoples. Although the tiger greatly diminished in numbers, in Kerinci he still forms a presence that cannot be neglected. The villagers find his footprints in their gardens; they might even meet him; or a dog, goat or cow might fall prey to the tiger. I estimate that every four to five years a human falls victim to the animal in Kerinci alone.

In the local concept of the tiger many seemingly controversial ideas mix. The tiger can be feared and respected, admired and distrusted, depending on the context. These ideas mirror an ambivalence that is characteristic of all sources of deadly power: it can help and harm you, save or destroy. In the last analysis, however, the tiger is thought of as a good and just animal, that is a friend rather than a foe to the Kerinci people. Many myths describe how the relationship between man and tiger was originally established (Bakels, in press). These stories tell us how in mythical times a deal was made between humans and tigers. The essence of this deal is that humans and tigers will not disturb each other, and respect each other's territory: the forest for the tiger and the village and the cultivated lands for the people.

The Kerinci people conceptually distinguish between several kinds of tigers. The main distinction is between the 'real' or factual tiger (*harimau biasa*) and the spirit-tiger (*harimau roh*). The 'real' tiger is regarded as one of Allah's creatures, just as the other animals are. Nevertheless he is thought to have a particular origin. Old stories speak of how the tiger (and the crocodile) originated from the sperm of an Islamic protagonist or from an amazingly potent male. At first the tiger was friendly and tame, and lived in the house of his 'creator.' But when he grew up he started killing the livestock of his keeper and was banned to the forest. There a deal was made between man and tiger. They were to respect each other's territory and not to disturb each other.

People's attitude to this 'real' tiger is ambivalent. It is thought that he can be mean and aggressive, but on the other hand he is seen as being 'one people' with the spirit-tiger, who would not harm human beings unjustly. It struck me how often characteristics of the spirit-tiger were also attributed to the 'real' tiger; in stories the two tiger-concepts often blend.

Generally it is thought that the tigers that roam the Kerinci forests are not 'real' tigers, but spirit-tigers (*harimau roh*). The spirit tiger is connected to the ancestors of the Kerinci people. Myths relate how, in ancient times a group of people came from the Minangkabau or the Jambi area, and settled in the hills of Kerinci. Here they married, often to what are really the first inhabitants of the area: the spirits (*mambang/bunian/jin*) or gods (*dewa*) that inhabit the forest. Maybe these forest-deities represent the old inhabitants of Kerinci, the people who carved and erected the megalithes found in the area. The offspring of these mythical ancestors form the Kerinci people. In these origin myths tigers play an important role. They are said to accompany these 'founding fathers' of Kerinci as a 'friend' or 'familiar' (*sahabat* or *akuan*) and sometimes it is thought that these first ancestors themselves turned into a tiger after their death. Also the forest-deities are thought to have a tiger as a friend, or to manifest themselves as such. In practice the spirit-tiger is thought of as a manifestation of these first inhabitants: ancestors and/or forest deities. As such, he plays an important role in the social, ritual and mystic domain.

Spirit-tigers are regarded as just and morally good animals. They protect the village against the 'normal' tiger and the gardens against pigs. When somebody of the village would get lost in the jungle, the spirit-tiger would lead him to the edge of the forest (a method well worth remembering: tiger-tracks often do lead to man-made roads).

The communication between man and the spirit-tiger is in the hands of the *dukan* and the *adat*-leaders. During the yearly ritual of *Kenduri Seko* the bond between tiger and humans is reaffirmed. The *Kenduri Seko* is a celebration in honor of the (first) ancestors, the hereditary titles and the holy goods they brought. Central to this ritual is the passing of the hereditary titles of the village-heads to their successors and the homage paid to the holy hereditary goods (*pusaka*) that were brought by the first ancestors (and are therefore connected to the titles as well). During the celebration the ancestors are honored with offerings such as flowers and rice presented to them in the house. Outside the house offerings are presented as well, including raw meat and blood of a water-buffalo that has been slaughtered for the occasion. These offerings are meant for the spirits of the forest, including the spirit tiger. In some villages it is still a tradition that a newly appointed village-leader brings these offerings to (among others) the spirit-tiger: a reflection of the importance of an ongoing relationship between the two. If the tiger would not get this yearly token of respect, or when the *Kenduri Seko* would not be held altogether, it is feared that the tiger would leave the forest and disturb the villagers.

The *Kenduri Seko* can be seen as a reenactment of the founding ritual of each Kerinci village. Oral tradition has it that the founder of the first Kerinci village slaughtered a water-buffalo on a special stone and buried part of the buffalo under it. This offering had to seal a good relationship of the founder with the gods, the spirits, the wild animals (especially the tiger), and the (or his) people. So traditionally, we may conclude, the relationship of the Kerinci people with the surrounding powers of nature (real and supernatural) is one of respect and cooperation. Rules were made to direct this 'good relationship,' and breaking of the rules had - and still has - severe consequences for both sides as I will show later (see crime and punishment).

Dukun also have more individually colored relations with a spirit-tiger and consider them as a 'friend' (*sahabat*) or 'familiar.' The spirit tiger they befriend can be the manifestation of the first ancestors, as was described above, or a more recently deceased relative. The tiger may be called in times of illness and asked for a recipe, mostly consisting of special kinds of herbs. *Dukuns* also say they can ride on these tigers and instruct them to guard their fields. The spirit-tiger is also considered a master in the Indonesian martial art, *pencak silat*. The highest form of silat is the *silat harimau*. Tales tell how originally this silat was learned from a tiger, and a silat teacher will never practice the *silat harimau* without asking the tiger's permission first. When in severe trouble someone might call the spirit-tiger, whose energy can enter the person in need and fill him with a tigerish power. Adversaries, it is said, then see this person as if he were a tiger. Also the spirit-tiger may come himself and confront the aggressor.

I should remark that in most cases this 'friend' is considered to be the spirit-tiger, but in the north of Kerinci, people also told me there were people (*orang bakung*) who befriended 'real' tigers. This might be an example of how often the two categories blend.

Apart from the two discussed main categories (the real- and the spirit-tiger), another remarkable group of tigers should be briefly mentioned. These are the tigers from Pasemah. It is the Kerinci version of an all-Indonesian idea (see Hazewinkel and Wessing: 1986) that, hidden in the deep jungle, lies a village where the tiger-people live. The Kerinci people locate this village in Pasemah (Bengkulu). In their village the tiger people are humans, outside their village they change into tigers. During four months each year their king sends his subjects on a hazardous mission. They have to collect human hearts for his dish. These tigers are very much feared, and *dukun* in many Kerinci villages have the task to magically ward off the danger.

Not everybody in Kerinci agrees on the behavior of these Pasemah tigers. Some maintain they are vicious, others that they will not harm a human being, as long as the *adat*-rules are not broken. Characteristics of the 'real'- and the spirit-tiger are recognizable in the Pasemah tiger.

INTO THE FOREST

The Kerinci habitat of the tiger covers the forest, and also the forestry-gardens on the slopes of the valley. To understand the local conception of the tiger, it is important to understand the conception of his habitat.

In the West the forest is thought of as a neutral domain, to be exploited or protected for respectively economic, ecological or recreational means. In Indonesia the forest is often conceived of as a world in its own right. It is the abode of nature spirits (in Kerinci the *mambang*, *bunian* and *jin*) and of the founding ancestors of the several villages in the valley.

The wild animals of the forest are considered the livestock of the forest-spirits, who herd them, as humans herd their livestock. The forest thus appears not as a neutral or objective domain, but as a cultured abode as well, a 'culture of the beyond' (Schefold 1988), that is to be met on its own terms. Consequently if one wants to enter a primary forest-plot, to walk through, gather forest products or to hunt, the local supernatural beings have to be asked permission first. During a stay in the forest (and the forest gardens) one has to obey a specific set of rules and regulations in order not to disturb or offend the inhabitants. One should not talk loudly and one should behave politely.

It is especially dreaded to offend the tiger, the might 'keeper' and 'king' of the forest (*penghuni/raja hutan*). Primarily one should not speak disrespectfully of the tiger (a man from Keluru village, who once tested this taboo, told me that the next day he found tiger-scratches all around his garden-hut as a warning), and never call him by his direct name. Also all behavior that is associated with that of the tiger is forbidden: walk on all fours, sit with a knee high, take a wooden pestle to the garden (associated with the tiger's tail), eat directly from the pan (*priuk*), etc. Some people protect themselves against possible danger by carrying special amulets. The tiger is especially fond of 'pregnant maidens' (*bunting gadis*); a woman pregnant for the first time. He is said to lick her footprints with relish. Pregnant maidens will never go to their gardens alone, and they protect themselves with amulets. Generally people hold the idea that if one respects the rules of the tiger and forest-spirits once in their domain, there is no need to fear repercussions.

CRIME AND PUNISHMENT

In the human domain, the daily life of the villagers, these supernatural powers play an important role as guardians of the traditional rules of behavior, the *adat*. It is especially the tiger who serves as a judge and protector of the traditional *adat* laws.

While the ancestors were the progenitors of the Kerinci *adat*, it is the ancestral tiger who watches over it. As was laid down in the original oath between humans and tigers, the latter will never disturb humans, with the exception of people who have trespassed the *adat*-rules. In the same way the former do not have the right to kill tigers unless a tiger has attacked a man or his livestock first. Even then, the tiger has to be interred with the proper rituals. Otherwise, the tiger people would come to revenge themselves.

In Kerinci, when a tiger suddenly shows himself during daytime in the neighborhood of the village, when his footprints are suddenly frequently found, the message is understood. Something in the village is wrong. Somebody has broken the *adat*-rules. Maybe somebody has committed adultery or failed to obey the assignments of the village-leaders. Or maybe the village-leaders themselves have failed in the performance of their tasks. People are too afraid to go to the gardens and discuss the situation. Often they have a suspicion about the cause of the tiger's rage, and social pressure is put on the suspect. Generally the person reports his crime to the *dukun* and the *adat* leaders (*depati/depati nenek mamak*), who will impose a penalty. This will be a certain amount of rice, and a chicken or goat. The animals are slaughtered and eaten. The *dukun* or one of the village-chiefs will bring some of the meat to the forest and inform the tiger that the fault has been corrected.

If a tiger goes as far as to attack livestock or even a human being, the tiger has gone too far. Even though it was done by the spirit tiger and the killing may be a just deed, there has to be revenge. If the killing was done by the 'real' tiger, it may be just a mean deed and the animal will have to be killed as well. Some people say that if a tiger kills livestock or a human, it is always the 'real' tiger who is given leeway by the spirit-tiger, who normally would protect the area against these types of tigers. Others maintain that if the animal returns to his bait the next night and is shot, it is a real tiger. If the tiger doesn't return, it is the spirit tiger.

On an analytical level we could say the 'just' tiger performs an important function as a guardian of the human social order. It is interesting to note that he seems to punish, where human means fail; in case of adultery there is no proof, in case of misbehavior by village-chiefs there is nobody in a position to convict them. Also, a psychological fear of an uncontrollable, lurking physical danger is transformed into a controllable social behavioral pattern. "If misfortune cannot be neutralized, it can at least be rationalized" (Valeri, 1985).

In Kerinci, traditionally several methods are used to kill a guilty tiger. Most widespread I found is a type of fall, consisting of a slowly mounting plank. Under the plank, sharp bamboo sticks (*ranjau*) are firmly planted in the ground. When the tiger walks on the plank and gets the bait, the plank will drop and the bamboo sticks will spear the tiger in his belly. I have also heard of a case in which a snare in the form of a slipknot from bamboo was made, and successfully used. From the time fire-arms were introduced in the region, probably by the Dutch in the beginning of the century, local hunters have used these to kill the tiger. They waited with lamp and gun in a tree above the remains of the attacked animal. In several cases Dutch and later Indonesian policemen were asked to kill the tiger.

In all the cases involving local huntsmen, incantations are used to call the tiger. In the incantations it is stressed that the tiger has trespassed the laws and has to receive his rightful punishment. Sometimes the leader of the tigers is addressed and asked to send his guilty subject to the trap to pay his debt. It is presumed that only the guilty tiger will come back to the bait.

Remarkably in Kerinci there is no tradition of building a cage to catch the tiger, as is done by the neighboring Minangkabau (Kartoni, 1978). In some recent cases a Minangkabau tiger-specialist (*pawang harimau*) was involved in Kerinci and caught a tiger in a cage. Everybody I have spoken to absolutely denied they would ever try to catch an innocent tiger.

Although the tiger is guilty, he is killed with respect and his body is ceremonially buried. Before the interment his dead body is resurrected (called *bangung*; to wake up, bring to life) on a bamboo frame. In front of the tiger men and women dance (*pencak silat*) in his honor and incantations are chanted:

> Oh grandfather
> Grandfather crippled tiger
> Who is the guardian
> Of the Kingly Mountain

Oh grandfather crippled one
Your grandchild did not behave well
Your grandchild already got lost
And he has to pay his debts
Your laws have been broken

Oh grandfather the crippled one
The *kris* of old time should not shudder
The mirror of former days should not be blurred
Your grandchild already has blood on his paws
The fence has been opened, the border trespassed

Words of the old days we are looking for
Words, that have to be remembered
The debt has to be redeemed
The smoldering fire has already been quenched

CONCLUSIONS

Today, the `king of the forest' has become an endangered species that calls for protection. I have tried to show how in the present worldview of the Kerinci people the tiger takes a respected position, although its role is not free from ambivalence. As generally in Kerinci tigers are considered spirit-tigers, who are respected and whose position is deeply rooted in the traditional worldview of the people, they do not have to fear any danger from the villagers. There exists a delicate relationship between tiger and man, forged in a mythical and holy past. As an outsider I would say the conception of the relationship is inspired by common sense, respect and fear.

Common sense because, as many biologists have stressed, tigers seldom attack humans. The Kerinci people are well aware of that and many have experienced close encounters with tigers in the field where nothing happened. That is, nothing happened physically. Some people got so frightened by finding themselves vis-a-vis the tiger that they stayed in a condition of shock for several days.

Maybe we can apply the term `balance of power' to the man-tiger relationship. It is appropriate that because the tiger is feared and has the power to kill, he is not attacked without reason. The human killer would fear the revenge of the tiger-people. For that reason, it is my opinion that a Kerinci hunter, living a rural life in his village, would never attack an `innocent' tiger. As part of the traditional system, he would never hunt a tiger without permission of the local leaders, who, for reasons I have explained above, would never give it. Even if the hunter would not fear revenge, the other villagers would not accept such an endangering of their lives. Probably this mechanism has protected the tiger, but it permitted the traditionally respected, but less feared animals such as the elephant, rhinoceros and deer to be hunted for meat and medicinal or economical gain. Under the influence of demographic pressures and new economic opportunities new values have started to dominate the traditionally held respect for these animals, and other priorities, such as direct economical gain, have been chosen (see also Persoon, 1991).

Based on the conversations I had on this subject with the village youth, I got the strong impression that they hold the same opinion of the tiger as their parents. The here described 'traditional' worldview still forms a living tradition that will not die out within one generation. However men who have left their village and, for example, joined the army or police force (and thus have access to guns) form another category, as does the heterogeneous population of Kerinci's capital Sungai Penuh. In these cases new rationalizations and opportunities erode the traditional patterns. Control on poaching will have to be part of the Kerinci project, as it will have to be part of any program on nature preservation in the world.

Finally, respect, awe and even feelings of friendship and solidarity color the tiger concept--feelings that resound a time in which mankind did (and could) not subdue nature but tried to live in cooperation with it. Because of this traditional respect for tigers, the case for Kerinci offers promising opportunities. It is important however that these ideas are stressed and preserved for the generations to come. To this aim the World Wide Fund for Nature (WWF) and the Indonesian Directorate of Forest Protection and Nature Conservation (PHPA) could set up an educational project. In dealing with the local people it will be indispensable for the WWF/PHPA staff to 'talk the same language,' to understand and to respect local conceptions of nature and animals.

Summing up the social universe, the cultural conception of the tiger encompasses the natural universe. The tiger is not seen as a random killer, but as an ancestral figure who protects and punishes only those who have violated the law. Thus, in Kerinci, not only the people watch over the tiger, the tiger watches over the people.

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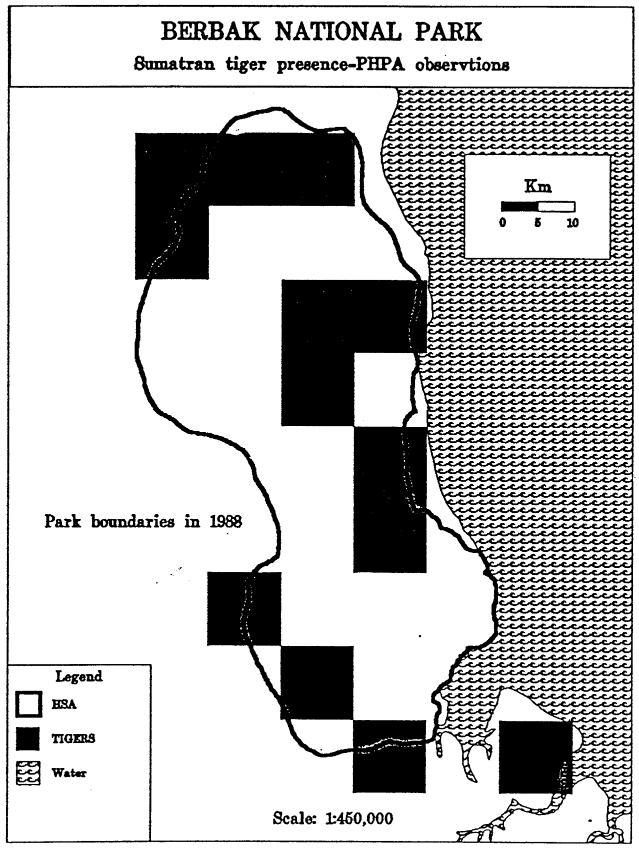
SUMATRAN TIGER

POPULATION AND HABITAT

VIABILITY ANALYSIS WORKSHOP



GIS analysis of Berbak National Park, Sumatra.

SECTION 5

SUMATRAN TIGER DISTRIBUTION AND STATUS

CONSERVATION OF SUMATRAN TIGERS IN INDONESIA

Widodo Ramono, PHPA and Charles Santiapillai, WWF-Indonesia

INTRODUCTION

About the turn of the century, there were three subspecies of the tiger (*Panthera tigris*) in Indonesia: *P.t. balica* in Bali; *P.t. sondaica* in Java and *P.t. sumatrae* in Sumatra. Today however, both Bali and Javan tigers have become extinct and only the Sumatran tiger survives. The extinction of the two sub-species of tiger in Indonesia was both rapid and deliberate and it occurred at a time when conservation was already the accepted national policy (Ashby & Santiapillai, 1987). This fact underlines the inherent difficulty in conserving a large predator in environments dominated by man. It shows clearly that much more than mere legal protection and reservation of habitat is needed to safeguard the species in the wild. It therefore calls for a more discretionary and selective strategy to replace our current strategy of responding to crisis in the management of carnivores in general and the tiger in particular. The ecological and behavioural factors that restrict the tiger's range in Sumatra likewise make it susceptible to pressures from man's modification of its habitat. Because of its vulnerability to a spectrum of limiting factors, the tiger in Sumatra faces precarious prospects if its present distribution were to be substantially reduced and populations become small, fragmented and isolated from one another. In Sumatra, tiger habitat is shrinking fast and unless prudent policies are adopted to exploit the timber resources on a sustainable basis, by the year 2000, the tiger will almost certainly be confined to a few large and well protected reserves.

DISTRIBUTION OF THE TIGER

Sumatra prior to 1900 was largely covered in primary forest from Aceh in the north to Lampung in the south. Up to that time, the tiger, although its population density would have been low, was more or less continuously distributed throughout the entire island. Less than a century later, as a result of conversion of primary forest to agricultural holdings, the tiger distribution has become fragmented and substantially reduced (Fig. 1). However, tiger is found in all the eight provinces although in highly populated areas such as the provinces of North Sumatra and Lampung, the animal has been squeezed out of much of its former range.

The fact that the tiger still survives in all the eight provinces in Sumatra points to its adaptability and versatility. However, there are strict limits to its versatility: what is probably particularly important is a variety of mammalian herbivore species being available as prey, fresh water and ample vegetative cover (Schaller, 1967). These requirements are largely met within the network of protected areas in Sumatra (Fig. 2).

There is definite evidence for the presence of tigers in 26 protected areas in Sumatra (Table 1). These areas total 4,564,121 ha or 45,641 km^2 and account for 9.63% of the total land area of Sumatra. Within these areas, the tiger inhabits an altitude range from sea level to over 1,000 m (Blouch, 1984). In addition, tigers are also known outside the network of protected areas, especially in rubber plantations where many of the attacks on man and livestock have been reported.

NP = national park
GR = game reserve

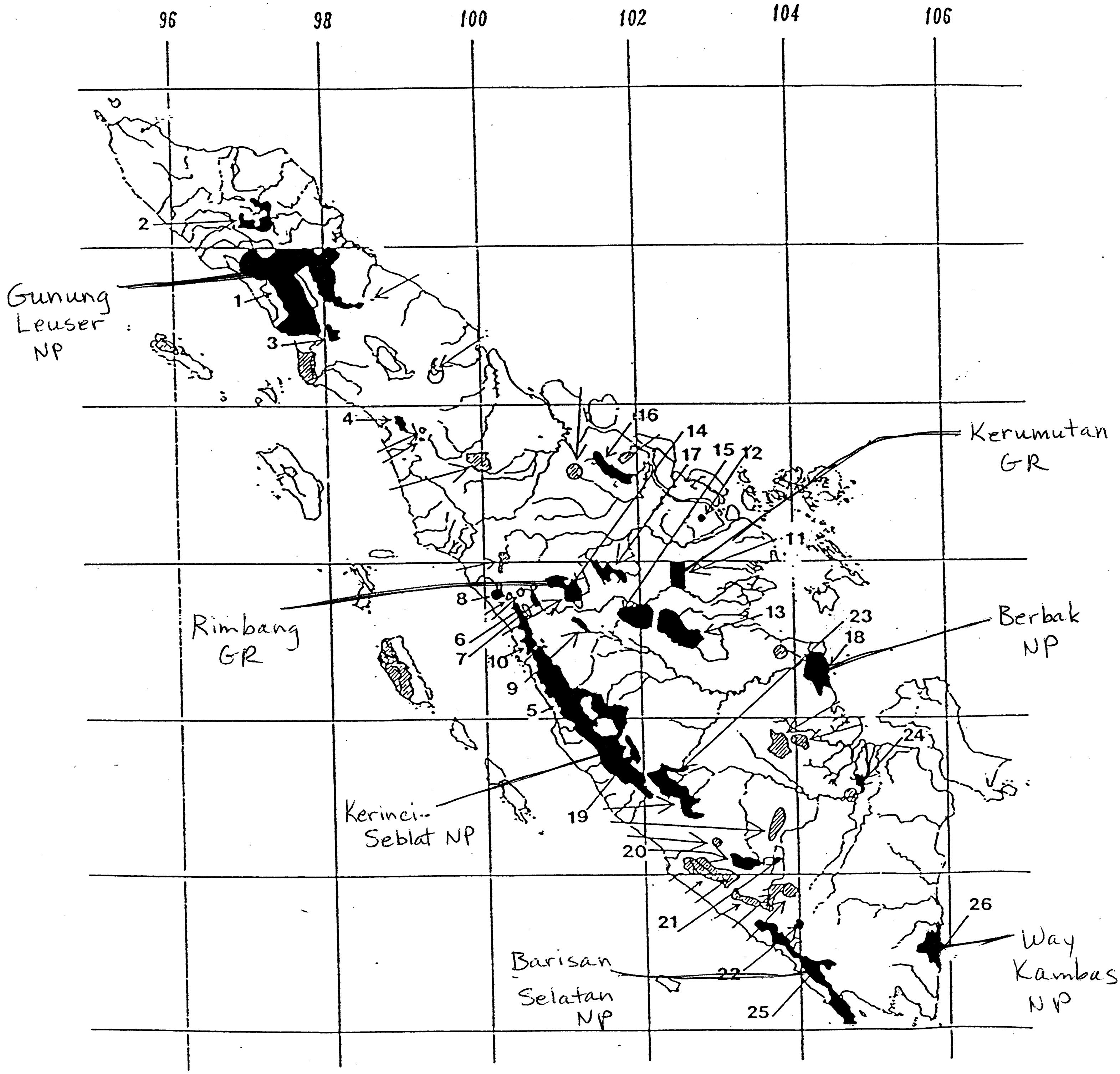


Fig. 1. Distribution of Sumatran tiger (*Panthera tigris sumatrae*). Solid shading: positive evidence of presence of tiger. Cross hatching: extent of additional suitable habitat but where positive evidence is not available. Numbers refer to the areas indicated in Table 1.

~~map~~ Protected areas with wild Sumatran tiger populations (five national parks + two game reserves)

Table 1. Protected areas of Sumatra where tigers are found.

No.	Reserve/Park/Forest	Prov.	Status	Area (ha)	Alt. (m)
1	Gunung Leuser	Aceh	NP	792,675	0-3419
2	Lingga Isaq	Aceh	HR	80,000	800-2823
3	Dolok Sembelin	NSum	PFo	33,910	150-1604
4	Sibolga	NSum	NR	20,100	200-1230
5	Kerinci-Seblat	WSum	NP	1,484,650	500-3800
6	Lembah Anai	WSum	PFo	96,002	600-1811
7	Lembah Harau	WSum	PFo	23,476	600-1256
8	Maninjau	WSum	PFo	22,106	600-1724
9	Bkt.Sebelah/Pangean	WSum	PFo	22,803	600-1078
10	Bajang Air Tarusan	WSum	PFo	81,865	500-2000
11	Kerumutan Baru	Riau	GR	120,000	0-0
12	D. Pulau Besar/Bawah	Riau	GR	25,000	0-0
13	Seberida	Riau	NR	120,000	150-830
14	Bkt. Rimbang/Baling2	Riau	NR	146,000	200-1090
15	Peranap	Riau	HR	120,000	120-492
16	Siak Kecil	Riau	NR	100,000	0-20
17	Air Sawan	Riau	GR	140,000	100-176
18	Berbak	Jamb	GR	190,000	0-20
19	Merangin Barat	Jamb	PFo	64,600	1000-1931
20	Gumai Pasemah	SSum	GR	45,883	200-1776
21	Isau-Isau Pasemah	SSum	GR	12,114	500-1431
22	Gunung Raya	SSum	GR	39,500	300-2232
23	Rawas Hulu Latikan	SSum	GR	213,437	300-2384
24	Padang Sugihan	SSum	GR	75,000	0-50
25	Barisan Selatan	Ben/Lam	NP	365,000	0-1964
26	Way Kambas	Lamp	GR	130,000	0-50
	Total			4,564,121	

NB: NP=National Park; NR=Nature Reserve; HR=Hunting Reserve; GR=Game Reserve; PFo=Protection Forest. Underlined areas are lowland forests.

Fig. 2 The extent of forest cover in Sumatra.

Rainforest habitat in general does not support a high biomass of large ungulates (Eisenberg & Seidensticker, 1976). On the other hand, lowland forests support a greater biomass of ungulate prey such as wild pig (*Sus scrofa*), sambar (*Cervus unicolor*) and barking deer (*Muntiacus muntjak*) which are among the species preferred by tiger in Sumatra (Santiapillai & Widodo, 1987). But it is precisely such lowland forest habitats rich in prey species that are fast disappearing in Sumatra as a result of a host of development programmes. It is estimated that between 65% and 80% of the forests in the lowlands of Sumatra have already been lost (Whitten *et al.*, 1984). The mountain areas to date have been less seriously affected, but disruption of continuous cover is already substantial in some cases, and perhaps 15% of their total area may tentatively be estimated as already removed on the evidence available.

Optimum habitat is provided by sub-climax vegetation. Ecotonal habitats are particularly favourable to tiger, as such transitional zones between forest and grasslands support a higher density of tiger's principal prey species.

NUMBER AND DENSITY OF TIGER

The dense and tangled vegetation of the tropical habitats in Sumatra makes it extremely difficult to arrive at even working estimates of the tiger number and density. As the animal is rarely encountered in the forest, much of the data regarding its presence and number must come from information obtained from people living in or around the areas inhabited by tiger and also from the study of the pug marks (McDougal, 1977; Panwar, 1979).

In 1978 Borner surveyed Sumatra and estimated the number of tigers to be about 1,000. Since then, Sumatra has undergone much development and subsequently, the extent of prime tiger habitat has declined. Subsequent surveys of Sumatran tigers in 1984/85 by Santiapillai and Widodo (1985, 1987) put the number not in the thousands but in the "hundreds".

In the optimum habitats in India, tiger densities can be as high as 14 per 100 km^2 (Sankala, 1979). In prime habitat in Nepal, adult tiger densities of 6-7 per 100 km^2 have been recorded, whereas outside such areas, densities are much lower, about 1-2 per 100 km^2 (McDougal, 1977; Smith, 1978; Sunquist, 1981). In Sumatra, tiger densities could be as high as 3.7 per 100 km^2 in such prime tiger habitat as the lowland forests in Bengkulu province (Santiapillai & Widodo, 1985). But this is exceptional and in general, much lower densities are the norm in Sumatra. The tiger in Sumatra can maintain a density of 1 per 100 km^2 in mountainous areas and 1-3 per 100 km^2 in more favourable lowland habitats (Santiapillai & Widodo, 1987).

Of the 26 areas where tigers are known to occur (Table 1), 14 represent lowland forests (underlined in Table 1) and these account for 1,339,488 ha or 13,395 km^2 while the remaining 12 montane forest habitats make up 3,224,633 ha or 32,246 km^2. Taking the maximum density of 3 per 100 km^2, the lowland habitats could support a maximum of 400 animals while, at a density of 1.5 per 100 km^2, the montane areas could support about 484 tigers. On such flimsy estimates, the network of protected areas in Sumatra could support about 800 tigers.

CONSERVATION IMPLICATIONS

The tiger finds itself with its back against the wall in Sumatra. The tiger's prospects for long term survival appear to be grim in a number of protected areas given their small size. Only 12 areas out of the 26 tiger reserves in Sumatra are larger than 1,000 km^2. The smaller reserves are unlikely to support viable tiger populations in the future. Such small populations of tiger currently occurring in these reserves are very vulnerable to local catastrophes. Random changes in the populations, such as marked fluctuations in the sex ratio, have proportionately more impact in smaller populations (Bertram, 1986). One way of avoiding some of the problems associated with managing small populations of tiger would be through the establishment of forest corridors to link smaller reserves with the larger ones - if this is still feasible.

Reserves also need to be zoned and managed. Strict protection must be given to the core areas where the tiger and its prey populations could survive without any interference from man. Multiple-use zones around protected areas are an important feature of the Indian tiger reserves (Bertram, 1986). Our objective is to maintain viable populations of tiger in Sumatra in as many areas as possible without leading to unacceptable conflicts with livestock and human settlements. This is the difficult management goal facing us: how to increase the number of tiger in the wild at the same time reduce the conflicts such an increase will have with humans and their livestock? Tigers being territorial animals, they will eventually space themselves out in any area, thereby force the surplus animals into outlying areas such as buffer zones and multiple-use zones. Conflicts between such transient tigers and man are inevitable in heavily populated areas.

Given the size of the human population in Sumatra, the number of people killed by tigers is indeed very small. Motor cars and snakes kill more people than tigers but attacks on people by tigers, however rare, are given prominence in the press. More common however are attacks on cattle. Such tiger depredations on livestock must be reduced and the farmers and stockmen who suffer such losses must be compensated, otherwise the tigers will forfeit acceptance by the local people, and without local people's support, no conservation program will achieve its desired goal in the long run. If the losses of livestock are exceptional and sustained, then they should be offset by some sort of compensatory adjustment on the part of those who benefit from the predator's survival viz, the society at large (Myers, 1976).

Problem tigers such as "man-eaters" and chronic stock raiders could be captured and accommodated in zoos, where they could be bred and maintained as an insurance against extinctions in the wild *[Editors' note: This recommendation was incorporated into the PKBSI Sumatran Tiger Captive Breeding Masterplan].*

RECOMMENDATIONS

In spite of losses of habitat to date, there is still time for substantial tiger habitat to be maintained, provided that it is not fragmented into inviable units (Ashby & Santiapillai, 1987). Given this situation, we suggest the following strategy:

1. Strengthen the protection of the five key areas in Sumatra such as Kerinci-Seblat NP, Barisan Selatan NP, Gunung Leuser NP, Berbak GR and Way Kambas GR. These key

conservation areas must be divided into core and buffer zones. Intensify the anti-poaching efforts of the guards.

2. Adopt a policy aimed at maintaining as much forest cover over large areas, uninterrupted by human settlements and roads where remoteness, difficulty of terrain and density of cover can provide natural protection.

3. Adopt a policy to keep as much unfragmented habitat outside the protected areas as is practicable on a long-term basis, as a multi-purpose forest where sustainable timber extraction is practised that is compatible with the survival of the tiger and its prey.

4. Identify areas chosen for new settlements in terms of compatibility with nature conservation as well as agricultural suitability to minimise conflicts.

5. Survey additional areas in Sumatra and determine the whereabouts of viable tiger populations. This applies particularly to the remaining unfragmented lowland forests where the species may be present.

6. Strictly control the use of poison especially around tiger reserves. The critical element in the decline of the Javan tiger in Ujung Kulon reserve in West Java was poisoning by nearby pastoralists (Hoogerwerf, 1970).

7. Design land-use patterns in the vicinity of tiger reserves in such a way as to make them compatible with tiger conservation and thus minimise human-wildlife conflicts. Adopt measures to improve the living standards of the people living along the periphery of tiger reserves. The farmers and herdsmen must be convinced that the conservation measures being taken are in their long-term interests, for without the support of the local people, all current efforts to conserve the tiger in Sumatra, whether in the wild or in captivity, are unlikely to succeed.

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POPULATION DENSITY OF SUMATRAN TIGERS IN GUNUNG LEUSER NATIONAL PARK

Mike Griffiths, WWF-Indonesia

BACKGROUND

Gunung Leuser National Park (GLNP) has an area of about 800,000 ha and lies in the northern part of Sumatra. The area is divided into two approximately equal halves by the Alas river which runs southward and flows into the Indian Ocean at Singkil. With the exception of the Kluet extension (12,000 ha), Sekundur (40,000 ha) and the upper Alas valley (1,500 ha), the entire area is mountainous and there are at least six mountains exceeding 3,000m altitude. East of the Upper Alas valley there is an extensive area of highland with moderate topography but for the most part the park is rugged and, particularly in the west, is almost impassable for man.

For those regions of the park that lie below 1,000m the vegetation cover is mixed dipterocarp forest. With increasing altitude oak forest predominates and finally at the highest elevations pines and rhododendron forests are typical with open alpine meadows covering the exposed areas. In the Upper Alas valley most of the land on moderate topography has been converted to agriculture. In places where the fertility of the soil has been depleted, beluka scrub and alang alang grass *Imperata cylindrica* has recolonised the previously cleared land.

Although GLNP is large, most of it is mountainous and thus unsuitable for many species. Of the species of fauna recorded in the park, 70% live in the lowlands, which account for less than 20% of the park's total area. These are the areas that are also the most threatened and in many cases are already modified. In 1981 most of the Sekundur was selectively logged on the justification of 'habitat improvement'. The Kluet is under constant threat and some was logged in the 1970's. The region of Upper Alas inside the park has been allowed to be settled illegally, although there are discussions at present about reversing this trend. All these areas are on topographically benign land below 500m, which are the richest habitats.

METHODS

Tiger inventory as a part of photo survey of GLNP

From 1985-1990 the writer carried out various camera trapping projects in GLNP. Initially these were self funded, but during the period from 1986-1988 the work was sponsored by Mobil Oil. Subsequently, during 1989-90, the author carried out a photo survey of the park as part of WWF's renewed involvement in the protection of the area. The majority of the work was carried out in two study areas, the Bengkung river system and the Upper Mamas valley (Fig. 1). The Bengkung river drains an area roughly 800 km^2 with altitudes ranging from the river basin at 100m to the northern watershed at 1700m. Much of the southern half of the catchment is on moderate topography with a highest altitude of approximately 600m. The Upper Mamas valley is smaller in area than the Bengkung (about 230 km^2) and is on average higher, ranging from 1,100m on the valley floor to 2,200m on the western watershed. Plants are less varied, the canopy is generally lower than the Bengkung, but all of the mammalian prey species found in the Bengkung are present here.

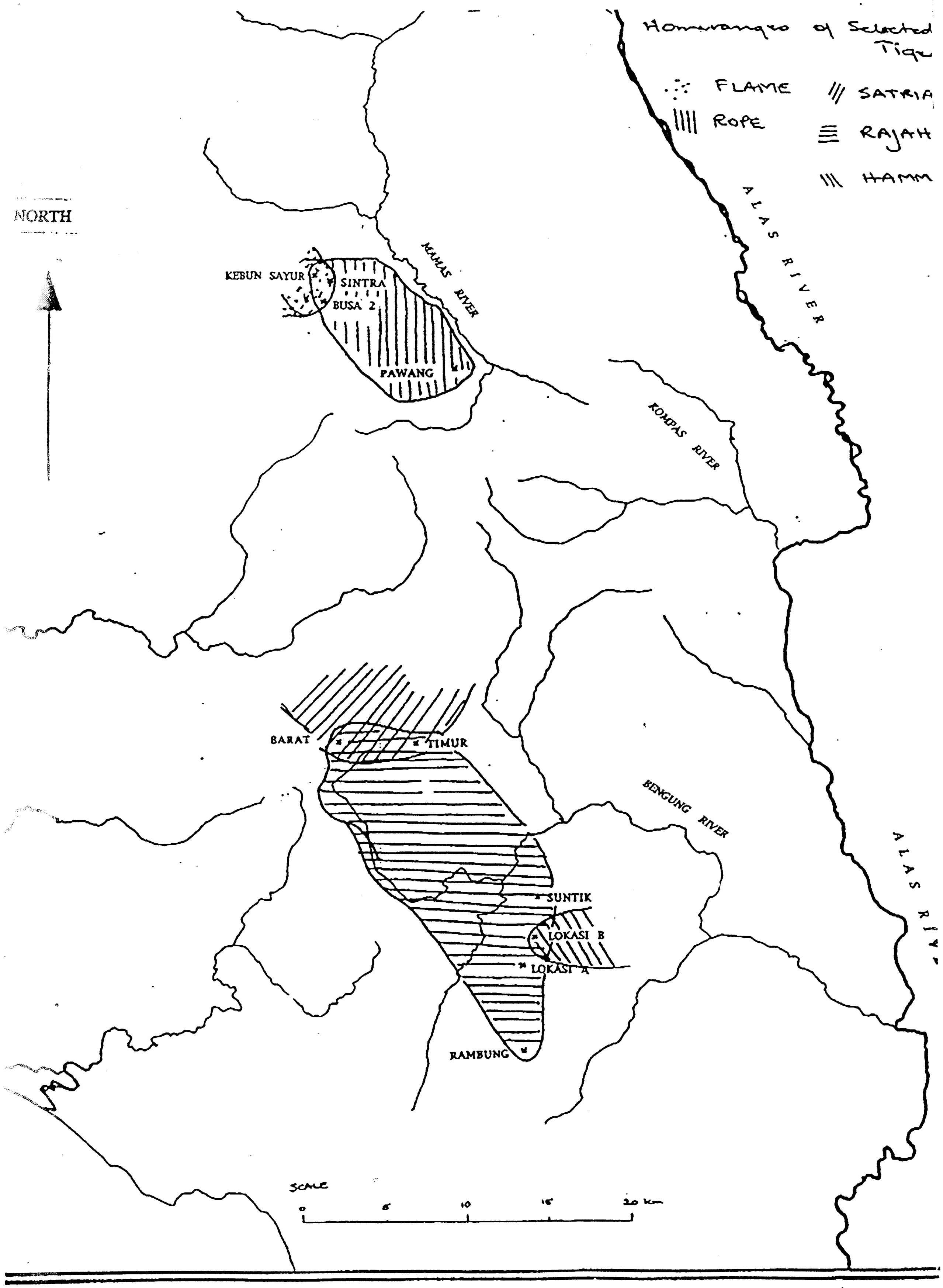

Fig. 1. Home ranges of selected tigers in study area of GLNP.

Camera trapping

Two methods were employed to gather data on the tigers in the two study areas: camera trapping and the study of tracks. Tracking involved following tracks of an individual tiger that had recently passed by a camera location, the idea being that by noting the approximate date of passing it would be easy to identify the tiger when films were processed. Following tracks allowed more comprehensive understanding of tiger movements in areas not covered by cameras.

Camera trapping used cameras which were set up beside game trails. The cameras were equipped with a simple triggering device such as a pressure mat placed on the path, and when an animal passes a camera location, it triggered the camera and an exposure (photo) was made. Electronic flashes were used so that the passage of nocturnal animals could be recorded. After each camera was set up the film was indexed by taking an exposure of a man holding a card (showing the name of the location) and a survey pole (for later use in measuring the animals photographed at that location). Films were collected every 4-6 weeks, processed and analysed.

Identification of individual tigers

The highest priority in analysing the films was to identify the individuals. Identification of tigers was based almost solely on stripe patterns, but, where applicable, body measurements could sometimes be used to differentiate individuals. Body size was gauged by comparing the size of the animal with the measuring pole photographed on the index exposure on the same roll of film. Care had to be taken to ensure that perspective errors were taken into consideration. For instance, the shoulder height of a tiger might vary as much as 3%. To get the best measurements, the placement of the front paws should straddle the point at which the foot of the measuring pole was placed at the time of the index exposure. Body length proved an unreliable parameter to use because of distortions inherent outside the central part of the photograph and because of apparent shortening when the animal was not exactly parallel to the plane of the film. The most useful areas on the body for identifying individuals were the sides of the abdomen, the face and the outside of the upper rear legs. The stripes here showed most variation between individuals and least distortion as the animals moved. Since many photos were taken from the side, problems could arise in deciding whether two patterns of stripes (from the left side and the right side) represented one or two animals. As it turned out there was in most cases a sufficient range of camera angles and animal orientations to allow positive identifications to be made in all except one case.

Identification of sexes

Male tigers were positively sexed by the presence of external genitalia. Females were identified when no external genitalia were present when viewed from angles that should have shown a clear view of the same. If a positively identified male was seen in the company of another adult, that adult was assumed to be a female if no other evidence was available. Female tigers had a less pronounced ruff around the face. Conversely, males photographed in GLNP almost invariably had a short mane on the back of the neck.

Activity times

Examination of the photographs would frequently reveal what time of day the exposure was taken. For simplicity, the daily activity periods were divided into diurnal, nocturnal and crepuscular. In reality, there were many occasions when the time could be determined more accurately by using the direction and angle of sun light, the pattern of shadows and the build up of condensation on a camera lens in early morning.

Miscellaneous information

Other things noted were the frame number of the exposure, the direction in which the animal was travelling, the number of individuals in a frame, and the time period in which the exposure was taken. Additional notes were made of anything thought to be significant, such as the condition of the animal, unusual activities when photographed, etc. After analysing the photographs the data were entered in tabular databases, one for the Mamas study area (Table 1) and one for the Bengkung area (Table 2).

Table 1. Tiger passes of camera traps in the Mamas study area.

Film in	Film out	Location	Fr#	A/S C	Sex	Dir	Di/No	N/pass	Name
Nov-90	Dec-90	Kb Sayur*		adult	m	lr	crep	1	????
Jun-90	Aug-90	Busa Dua	21	adult	f	rl	d	1	Flame
Nov-90	Dec-90	Kb Sayur	10	adult	f?	lr	n	1	Flame
Oct-90	Nov-90	Sintra	19	adult	f	rl	d	1	Flame
Jun-90	Aug-90	Busa Dua	19	adult	m	rl	d	1	Rope
Jun-90	Aug-90	Busa Dua	22	adult	m	rl	d	1	Rope
Sep-90	Oct-90	Busa Dua	6	adult	m	lr	n	1	Rope
Sep-90	Oct-90	Busa Dua	8	adult	m	rl	n	1	Rope
Sep-90	Oct-90	Busa Dua	10	adult	m	rl	d	1	Rope
Jun-90	Aug-90	Kb Sayur	11	adult	m	lr	n	1	Rope
Jun-90	Aug-90	Kb Sayur	22	adult	m	rl	d	1	Rope
Jun-90	Aug-90	Kb Sayur	30	adult	m	lr	d	1	Rope
Nov-90	Dec-90	Kb Sayur	7	adult	m	lr	n	1	Rope
Nov-90	Dec-90	Kb Sayur	13	adult	m	rl	n	1	Rope
Sep-90	Oct-90	Sintra	10	adult	m	lr	n	1	Rope
Jun-90	Aug-90	Pawang	30	adult	m	rl	d	1	Rope
Jun-90	Aug-90	Busa Dua	14	adult	m	lr	n	1	Titan
Apr-90	Jun-90	Kb Sayur	3	adult	m	rl	n	1	Titan

*Kebun Sayur

Table 2. Tiger passes of camera traps in the Bengkung study area.

Film in	Film out	Location	Fr#	A/S C	Sex	Dir	Di/No	N/pass	Name
Sep-88	Oct-88	Suntik	14	ad	m?	tow	d	1	????
Feb-88	Apr-88	Lokasi A	6	ad	f	lr	d	1	Barb
May-88	Jun-88	Lokasi A	11	ad	f	lr	d	1	Barb
Sep-88	Oct-88	Lokasi B	2	ad	m	away	n	1	Hammer
Sep-88	Oct-88	Lokasi B	4	ad	m	away	n	1	Hammer
Sep-88	Oct-88	Lokasi B	8	ad	m	away	n	1	Hammer
Jan-89	Feb-89	Suntik	9	ad	f?	away	n	1	Jan
Sep-86	Oct-86	Rambung	10	ad	m	rl	d	1	Kaiser
Oct-86	Nov-86	Rambung	24	ad	m	lr	d	1	Kaiser
Nov-86	Dec-86	Rambung	23	ad	m	rl	d	1	Kaiser?
Nov-88	Dec-88	Barat	2	ad	m	away	d	1	Rajah
Sep-88	Oct-88	Lokasi A	3	ad	m	rl	n	1	Rajah
Sep-88	Oct-88	Lokasi B	6	ad	m	away	crep	1	Rajah
Jan-89	Feb-89	Lokasi B	3	ad	m	tow	crep	1	Rajah
Sep-88	Oct-88	Rambung	19	ad	m	rl	d	1	Rajah
Jan-89	Feb-89	Rambung	11	ad	m	rl	d	1	Rajah
Jul-88	Aug-88	Suntik	7	ad	m	away	d	1	Rajah
Sep-88	Oct-88	Suntik	17	ad	m	away	crep	1	Rajah
Nov-88	Dec-88	Suntik	3	ad	m	tow	n	1	Rajah
Dec-88	Jan-89	Suntik	5	ad	m	away	n	1	Rajah
Dec-87	Mar-88	Timur	13	ad	m	away	n	1	Rajah
Dec-87	Mar-88	Timur	25	ad	m	tow	n	1	Rajah
Nov-88	Dec-88	Timur	4	ad	m	away	n	1	Rajah
Feb-89	Mar-89	Timur	1	ad	m	tow	crep?	1	Rajah
Apr-89	Jul-89	Timur	16	ad	m	away	d	1	Rajah
Dec-87	Mar-88	Timur	18	ad	f,m	away	d	2	(R+S)*
Jan-88	Mar-88	Barat	11	ad	m	away	d	1	Satria?
Jul-88	Aug-88	Lokasi B	6	ad	?	tow	d	1	Skinny
May-88	Jun-88	Suntik	8	ad	?	tow	d	1	Skinny
May-88	Jun-88	Suntik	5	ad	?	tow	d	1	Skinny

* (R+S)= Ratu and Satria

Limitations of the data set
Since the cameras were not specifically set out with the aim of delineating home range sizes of tigers, the information gained gives a picture of home ranges only of a few tigers. In other cases tigers would appear at just one or two locations and visits would be rare. Logistics also restricted the number of camera locations that could be located in the field. A typical camera set weighed 25 kg and it would take up to two weeks of overland walking to reach certain locations. Ten cameras covering the two different study areas representing a total area of about 140 km^2 were utilised. Because of this paucity of data it was impossible to get unambiguous information on the amount of overlap between adjacent home ranges. In most cases all tigers could be positively identified, but some were not, so no name was given to that individual.

RESULTS

Relevance of the whole park
Although the hills surrounding the Mamas and bordering the Bengkung to the North are high, they are not as steep and as dissected as in many other regions of the park. Additionally the valley floors are fairly flat and support good numbers of the preferred prey of the tiger: Sambar deer *Celvus unicolor*, pig *Sus scrofa*, and barking deer *Muntiacus muntjak*. These areas would thus be considered ideal for an unmodified rainforest environment. Taking into account topography, availability of water, and prey animals, there would be roughly 1,700 km^2 in GLNP that is comparable to the Bengkung and Mamas. Most of the remaining area is higher and more rugged, where the tiger would rely mostly on Serow *Capricornis sumatrensis* and barking deer for prey. In examining data on other species from the camera surveys, a relative value of tiger habitat can be estimated by comparing the frequency with which prey species pass camera locations in two different altitudinal ranges in the Bengkung study area (Table 3).

Table 3. Camera passes for prey species at different altitudes.

Species	100-600m	600-1700m
Sambar	04	00
Barking Deer	13	14
Pig	14	01
Porcupine	11	03
Serow	02	01
Totals	**44**	**19**
Total Camera weeks	**89**	**59**
No. of prey animals/yr	**26**	**17**

Higher altitudes are both poorer in prey species diversity (the sambar is absent and the pig almost so) and in density of suitable prey species (based on the frequency of camera passes). Assuming that the density of prey species is no greater in the even higher and more rugged parts of GLNP than 17 animals/year/game trail, then I estimate that the home range size of tigers in GLNP is proportional to the density of prey species and that the minimum home range size at higher altitudes would have to be larger by a proportionate amount. Although this is an over simplification, it may serve as a guide to estimate the home range sizes of tigers in less than optimum habitats.

Estimation of tiger home range size

Where there were records of an individual tiger having passed four camera sites or more, the area described by imaginary lines joining those locations was calculated and was noted as a measure of the minimum home range of that individual. An estimate of home range size calculated by the straight line boundary method gives a figure of approximately 80 km^2 for one male. If both camera information and fresh tracks were used for calculation, then the number is closer to being 90 km^2. **This minimum home range size in all cases was clearly an underestimate.** For example, tracks made by a male tiger were followed well to the west of the area confined by the lines connecting the camera locations, while the tracks of another male were followed for at least 12 km. This would effectively double the minimum home range size calculated by the straight line method. Other observers have noted that the lower regions of the Upper Mamas valley (90 km^2) might itself be only part of the territory for a large male tiger.

Given this sparse information, I estimate that, on average, the home range of male Sumatran tigers in the lowland forest (100-600m zone) would be about 180 km^2.

In only one case did a female tiger named Flame pass by more than one camera location. Thus, no information is available on the relative sizes of male to female home ranges in GLNP. Male Bengal tigers in the Royal Chitwan National Park, Nepal have home ranges roughly twice the size of females. If this ratio holds true in general for all tigers then it is reasonable to estimate home range sizes for female tigers in lowland forest in GLNP to be about one-half as large as male home range sizes, or about 90 km^2.

Sumatran tigers are found throughout GLNP to elevations at least as high as 1,800m. With increasing altitude, however, the frequency of tiger sign decreases progressively, probably due to fewer number of prey species. Tiger densities are less at higher altitudes but to what degree is largely guesswork. For the purpose of this paper, three altitudinal zones are used for estimating tiger home range sizes and population densities.

There are three broad tiger habitat types in GLNP: 1) the lowlands extending up to 600m; 2) hill country extending from 600m-1700m; and 3) the mountains which extend from 1700m-3000m. The lowlands could be further divided to include the forest edge. This region is potentially the richest tiger habitat of all; sambar deer are most common here and the densities of wild pigs (based on frequency of camera passes) are four times as high here as in primary forest. However, since 1986 extensive poaching of tigers has been carried out along the forest edge, especially in the west where the animals have been killed using poisoned baits. **Estimates vary as to how many tigers have been killed in this period, but second-hand accounts from the leading poacher indicate as many as 50 tigers were killed between 1986 and 1990.** Tiger numbers on the forest edge (much of which is still outside the park) have decreased and now pig numbers (that used to be controlled by tigers) have increased with subsequent loss of crops. Densities of tigers on the forest edge are probably now no higher than in the primary forest, so for the purposes of this population estimate it can be assumed that the forest edge and the lowland areas are a single unit.

Tiger population estimates.
Using the home range sizes already derived and for the moment assuming no range overlap the following population estimates of tigers (Table 4) can be given:

Table 4. Estimates of Sumatran tiger home ranges in GLNP.

Altitude (m)	Total area (km²)	Male range (km²)	Female range (km²)	Total
100 - 600	1,700	180	90	28
600 - 1,700	3,000	274	137	33
1,700 - 3,000+	3,300	380	190	27
Total population of tigers (assuming no overlap):				**88**

CONCLUSIONS

Adult tiger population of GLNP
According to the figures given above, the total population of adult tigers in GLNP would be about 88 animals. Undoubtedly there is considerable overlap of home ranges, especially among males, so actual home ranges would be larger. These two factors might partially cancel each other out. However, for the sake of argument, if it is assumed that there is an average of 50% overlap of all home ranges, then the new estimate for the population of adult tigers would be = 88 x 150% = 132.

Thus a best guess for the adult tiger population for Gunung Leuser National Park would be about 110 ±22.

Poaching issues. The main threat to the tiger in and around GLNP at the moment is poaching. Almost no local villagers poach the tiger. Partly this is for spiritual reasons, but there are also economic reasons (it is better to let tigers control pig populations than to build expensive fences around rice fields). Therefore almost all the poaching is done by outsiders. Poachers know this is illegal and they do it for profit. The concern is that when tigers are poisoned on the park's periphery, tigers from deeper within the park move in to the vacated and preferred areas. If the tigers are continually poached, the population of tigers deeper inside the park could be depleted even though no poaching is actually done in the interior. A more sinister aspect of this poaching is that it reduces the genetic diversity and may even work preferentially by taking out dominant individuals that utilise the best habitats on the edge of the park.

Fragmentation. In the long term the problem of minimum tiger populations needs to be addressed. If the corridor linking the Bengkung and the Singkil swamp is severed and the roads are completed between Blangkejeren and the east and west coasts, then GLNP will become to many animals an island. Although tigers are tolerant of humans and will cross large open areas, there is a limit, and the GLNP tiger population will one day become isolated. If the total number of tigers in the population is left at the lower end of the estimates given in this article, then the long-term future for the species in one of its last strongholds will be jeopardized.

Wildlife corridors. In order to mitigate against such an outcome there is an immediate need to secure the critical corridors linking GLNP to the large wild areas to the north and to the Singkil swamp to the south. There is a good chance that this can be achieved within the framework of Indonesian conservation law. Wildlife corridors are recognised for their importance and merit special consideration in regional planning.

Tigers, livestock and man. It is true that tigers attack livestock and on rare occasions people. Livestock can be well protected from tigers by being properly penned at night. In areas of Sumatra where tigers are frequently encountered, livestock pens are a common feature near homes. Maneaters should be eliminated, as having lost their natural fear of man, they could easily repeat the act, killing further people and increasing antipathy towards the many other tigers that prey exclusively on wild animals. It is worth pointing out here that for many hundreds of years up until recently the tigers living in and around the GLNP region left the people largely alone, and the people did the same to the tiger. Efforts should be made to encourage the continuance of this relationship. In doing so the tigers, given sufficiently large areas, should continue to live and sustain their numbers. With proper design of habitat and integrating this with the other needs of development there is no reason why the tiger will not have a long-term future, contributing to the welfare of the farmers, to the nation's tourist industry, and to perpetuating a balanced ecosystem in the forests of Gunung Leuser National Park and beyond.

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TIGER DATA IN WETLAND DATA BASE AND A RECOMENDATION TO ENHANCE THE CHANCES OF TIGER SURVIVAL

by

Scott Frazier

Asian Wetland Bureau

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TIGER DATA IN WETLAND DATA BASE AND A RECOMMENDATION TO ENHANCE THE CHANCES OF TIGER SURVIVAL

by

Scott Frazier
Asian Wetland Bureau

KOMPAS, Friday, 20 November 1992: *"Only perhaps 400 Sumatran Tigers Left"*

1. Introduction

This paper first concerns observation data on the Sumatran tiger (*Panthera tigris sumatrae*) compiled from various sources and stored in *Wetland Data Base* (See Appendix I). Given the grave situation facing this subspecies of the tiger, an existing recommendation is reiterated as a rational way to attempt to save this grand creature.

2. Tiger Observation Data in WDB

Wetland Data Base is *not* a species-centered data base, but nevertheless species observations from an important part of its inventory of information. WDB at present holds some 41 tiger records[1] from in and around 17 protected and/or important wetland sites in Sumatra (Figure 1).

A data base is by definition a secondary information source. It serves as a repository of information from many and varied origins. Some of these sources are merely compiled lists of species occurrence which lack specifics while others are more detailed survey accounts. This dichotomy is conducive to overlaps in the data where the original source of a list is not clear. For this reason WDB "flags" compiled lists. Given WDB's wetland focus, no attempt has been made to compile the sum total of observation data on the Sumatran tiger. And while many of the tiger data in WDB were derived from the 1980s literature, Figure 2 presents the *newest* WDB records for *Panthera tigris sumatrae*, most of which were collected by AWB and PHPA staff. [Appendix II presents a detailed version of the preliminary WDB tiger observation data set].

Data in Figure 2 are comprised of both valid physical observations and anecdotal information. In most cases local informant reports are routinely classified as "Unconfirmed" unless the researcher strongly feels the story has merit. The subjectivity is apparent.

[1] Each survey (or sub-survey entry if known) or simple compiled list without details, counted as 1 data record.

FIGURE 1. WETLAND DATA BASE TIGER SITES[1] AND RECORDS - Preliminary Data (Asian Wetland Bureau)

CODE	SITE NAME	DEG	MIN	LAT	DEG	MIN	LONG	RECORDS[2] Total	Last	
SUM04	Blok Kluet, T.N. Gunung Leuser	3	0	N	97	27	E	2	'91	O
SUM09	Dolok Sembelin	2	50	N	98	5	E	1	'87	R*
SUM17	Giam-Siak Kecil	1	6	N	101	39	E	3	'92	R
SUM19	Danau Bawah and Pulau Besar	0	37	N	102	11	E	1	'87	R*
SUM23	Kerumutan Baru	0	5	S	102	29	E	2	'92	O
SUM28	Rimbo	0	22	N	100	5	E	1	'87	R*
SUM29	Danau Maninjau Utara / Selatan	0	15	S	100	10	E	1	'87	R*
SUM31	Kerinci Seblat	2	5	S	101	25	E	3	'86	R*
SUM32	Lunang	2	20	S	101	0	E	1	'87	R*
SUM38	Taman Nasional Berbak	1	23	S	104	20	E	13	'91	O
SUM40	Bukit Gedang Seblat	2	52	S	102	10	E	5	'85	O
SUM45	Banyuasin Musi River Delta	2	15	S	104	53	E	1	'87	R*
SUM46	Padang Sugihan	2	55	S	105	10	E	2	'85	O
SUM47	Ogan-Komering Lebaks	3	35	S	104	45	E	1	'90	R
SUM48	Taman Nasional Sumatra Selatan I	5	15	S	104	15	E	1	'87	R*
SUM51	Way Kambas	5	0	S	105	45	E	2	'84	R
SUM65	Lematang River Peatswamps	3	0	S	104	0	E	1	'87	R

1 Site coordinates approximate; Some records from outside but in the vicinity of site boundaries.
2 Wetland Data Base records (earliest: de Wulf et al., 1981); Each survey (or sub-survey entry if known) or simple compiled list without details, counted as 1 data record.
O Tiger/sign observed.
R Reported only.
* Compiled list.

FIGURE 2. NEWEST WETLAND DATA BASE TIGER RECORDS - Preliminary Data (Asian Wetland Bureau)

REC.	SITE	DATE*	#	TYPE	EVID.	VALID	HABITAT	SOURCE
6	**SUM17**	09/1992	-	I	O?T?	U		K. Martin (pers. comm. 1992)
5	SUM17	11/1991	-	I	?	U	Peat swamp forest	Giesen and van Balen (1991)
9	**SUM23**	09/1992	-	O,I	B,OTV	Y		K. Martin (pers. comm. 1992)
28	**SUM38**	01/1992	-	OI	?	Y		B. Zech (pers. comm. 1992)
26	SUM38	09/1991	1	O,I	T,O	Y	Cultivated, former peat-swamp forest	Y. Rusila (pers. comm. 1992)
27	SUM38	09/1991	1	I	T	Y	Perennial riverine habitat	Y. Rusila (pers. comm. 1992)
22	SUM38	08/1991	3	O	T	Y	Peatswamp forest	HIMBIO (1992)
23	SUM38	08/1991	2	O,I	T,O	Y		HIMBIO (1992)
24	SUM38	08/1991	2	O	TC	Y	Riverine habitat	HIMBIO (1992)
25	SUM38	08/1991	3	I	O	U	Freshwater swamp thicket edge habitat	HIMBIO (1992)
1	**SUM04**	08/1991	1	O,I	T,OV	Y	Coastal dryland woodland	Rusila and Enis Widjanarti (1992)
2	SUM04	08/1991	1	O	OTC	Y	Lake shoreline with non-aquatic trees/shrubs	Rusila and Enis Widjanarti (1992)
37	**SUM47**	08/1990	-	I	?	U	Seasonally flooded non-peat swamp with unknown tidal regime; with grasses	Giesen and Sukotjo (1991a)
41	**SUM65**	08/1990	2	I	O	U		Giesen and Sukotjo (1991b)

KEY:

SUM04 = Blok Kluet, T.N. Gunung Leuser
SUM17 = Giam-Siak Kecil
SUM23 = Kerumutan Baru
SUM38 = T.N. Berbak
SUM47 = Ogan-Komering and Lebaks
SUM65 = Lematang River Peatswamps
# = Number of tigers observed or deduced from evidence.
* = Fieldwork date if known; otherwise, the publication date.

NOTE: A comma (,) between codes in the TYPE and EVIDENCE columns to be read as "respectively".
A memo for each of the above records is included in *Wetland Data Base*.

B = BODY PARTS
C = CLAW MARKS
I = LOCAL INFORMANT
L = COMPILED LIST (SECONDARY SOURCE(s))
O = OBSERVED/VISUAL OBSERVATION OF TIGER
S = SCRAPINGS
T = TRACK(S)
U = UNCONFIRMED; REQUIRES MORE INFO.
V = VOCALIZATION
Y = (CONSIDERED) VALID

Unconfirmed could mean either "doubtful" or "requiring further confirmation". Most of these recent records however are based on actual sign/or visual observations.

3. A Population of 400 Tigers?

What can be gleaned from these WDB records, especially in light of the implications of the *Kompas* daily headline translated at the start of this article? With a population statistic of 400 Sumatran tigers or the earlier population estimate of 600 tigers quoted in the same article, or even 800 (McDougal, 1977), very urgent consideration has to be given to the concept of the "*largest viable ecological unit*" (Santiapillai and Suprahman, 1984) for tiger conservation. In practical terms for Sumatra, this is the large tiger reserve (Santiapillai and Widodo, 1985). McDougal (1977) also addressing the question of tiger conservation strategies states, "All that we can expect is to maintain a few viable breeding populations of wild tigers in some places." Tigers, especially males, being large carnivores require large home ranges (Santiapillai and Suprahman, 1985, 1984; Santiapillai and Widodo, 1985; McDougal, 1977). And whether genetic viability of a population of a species like the tiger requires 50 breeding pairs (Santiapillai and Widodo, 1985 citing Franklin, 1980) or 300 individuals in a contiguous population (IUCN quoted by McDougal, 1977), there are very few sites capable of supporting either. In the latter case, there are no known *Panthera tigris* populations this large and genetic exchange is not regular between these populations (McDougal, 1977).

Santiapillai and Widodo (1985) offer 3 reserve choices for Sumatra. The first two, Gunung Leuser and Kerinci-Seblat being mountainous, are perhaps not choice selections since higher elevations do not support the highest densities of tiger (Santiapillai and Widodo, 1985; Blouch, 1984) and Gunung Leuser and Kerinci-Seblat are arguably cut in two by human inroads (PHVA Tiger Workshop, Padang, Indonesia, 1992).

4. Berbak

Santiapillai and Widodo (1985) describe the potential of the third possible reserve: "Of all the reserves in Sumatra, it is perhaps the Berbak Game Reserve (1,900 km²)[1] situated in the south-eastern part of Jambi province, which offers the long term survival possibilities for the tiger." They go on to say that these possibilities are, of course, predicated on effective protection of the tiger. de Wulf and Rauf (1982) had previously speculated that "Berbak also might be Sumatra's best tiger reserve".

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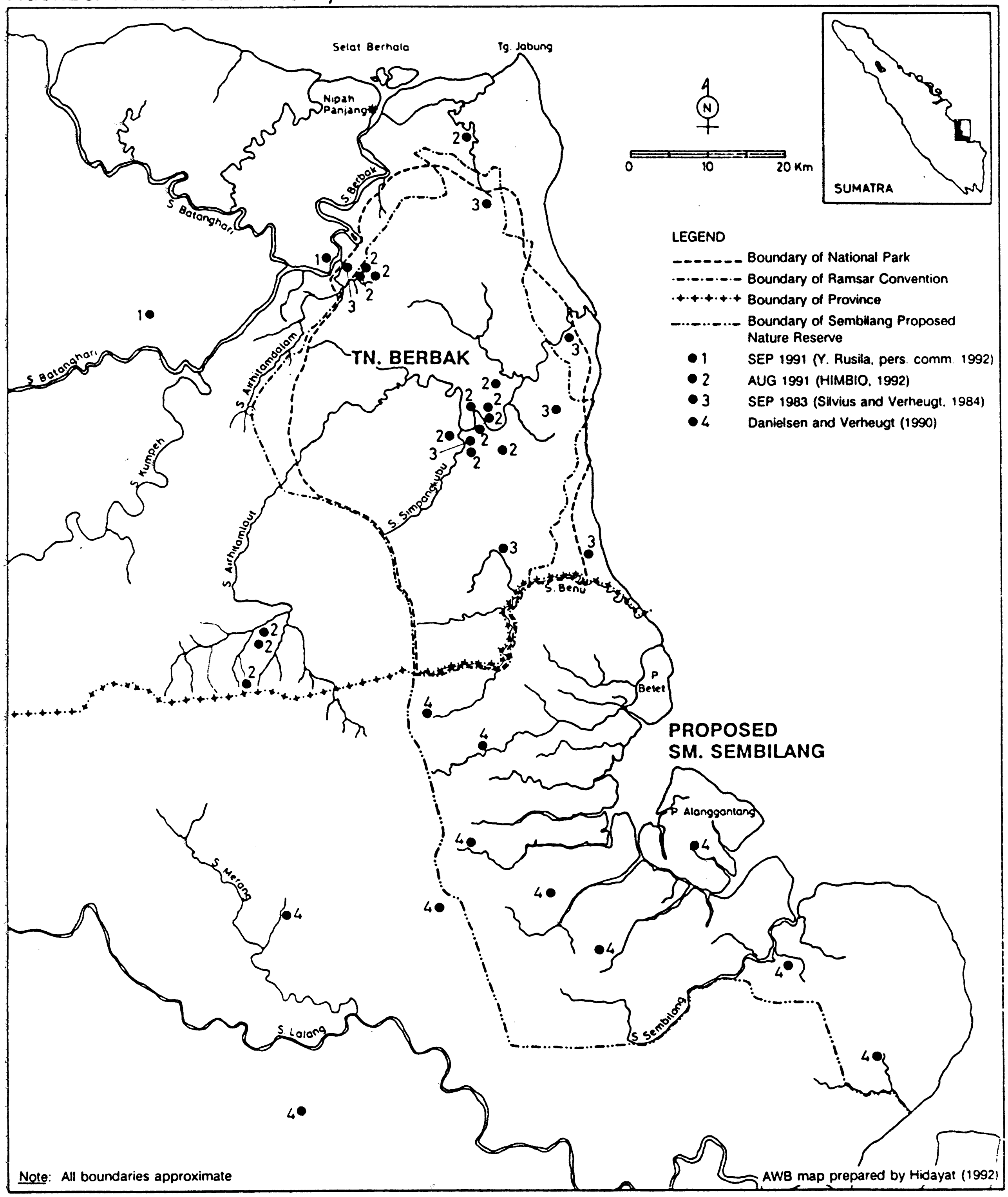
[1] Berbak, now a National Park, measures 162,700 hectares (Silvius and Giesen, 1992).

Perhaps it is not just survey bias that the majority of new WDB tiger records (Figure 2) come from in and around Berbak National Park. Likewise, Figure 1 reveals Berbak as the single site with the most WDB tiger records. Early on, de Wulf *et al.* (1982), perhaps over-zealously, proclaimed the tiger as Berbak's "most common large mammal". This title probably belongs to wild pigs in fact -- but tigers are certainly "numerous" (Asian Wetland Bureau, 1992). Blouch (1984) similarly stated that in southern Sumatra, tigers "are most common in Jambi" (and therefore Berbak) owing to the relatively undisturbed character of the forests there.

Figure 3 shows the approximate locations of tiger/sign observations from 4 sources in and around Berbak and to the south in the Sembilang Proposed Wildlife Reserve (Y. Rusila pers. comm., 1992; HIMBIO, 1992; Silvius *et al.*, 1984; and Danielsen *et al.*, 1990). Some of the observations occurred far outside the Berbak reserve proper, and close to human habitation. Silvius *et al.* (1984) saw tiger evidence in a range of Berbak habitats but not in peat swamp forest. While Santiapillai *et al.* (1985) interpreted this to mean that tigers are "absent in peat swamp forests", Silvius (pers. comm. 1992) explains that peat soil texture and/or a lower level of survey work in peat swamp forest (Asian Wetland Bureau, 1992) could explain the absence of observations. Silvius and Giesen (1992) list habitat for the tiger (among other species) as a benefit of peat swamp forests. In fact there are some equivocal accounts in WDB that indicate tiger observations at least in close proximity to peat swamp forest. This certainly merits further investigation given the fact that Berbak National Park contains two-thirds of all visibly undisturbed peat-swamp forest in Sumatra (Asian Wetland Bureau, 1992).

Still, does Berbak have what it takes to make a viable tiger reserve? Santiapillai and Suprahman (1985) citing Schaller (1976) state that there are three prerequisites for the tiger's survival in any habitat; namely the availability of adequate vegetative cover, sufficient water and abundant prey. It is evident from the foregoing that on the vegetative point, Berbak meets the requirement. Regarding water, Asian Wetland Bureau (1992) even ponders whether low lying land and high water levels might actually depress tiger densities somewhat in the park during the wet season, while acknowledging the tiger's "known adaptation to swamp habitat". Lastly many authors have pointed out that the tiger's preferred prey, wild pig and/or deer (Santiapillai and Widodo, 1985; Santiapillai and Suprahman, 1984; Silvius *et al.*, 1984; de Wulf *et al.*, 1982) is plentiful within Berbak (Silvius *et al.*, 1984; de Wulf *et al.*, 1982). The *fact* of Berbak's uniqueness and rich biodiversity is well documented albeit not completely known. Giesen (1991) summarizes the studies carried out at Berbak through 1990. Asian Wetland Bureau (1992) quoting Petocz (1987) and MacKinnon and Artha (1982), respectively, states that "Berbak is the largest freshwater swamp forest in Sumatra, and one of the

FIGURE 3. TIGER OBSERVATIONS/SIGN FROM 4 STUDIES IN AND AROUND BERBAK



Note: All boundaries approximate

AWB map prepared by Hidayat (1992)

largest in Indonesia" and "it contains the most extensive peat swamp forest in the Pacific realm." Furthermore, more than 30 mammals, almost half of Sumatra's bird fauna (257 species) and approximately 300 species of plants have already been recorded in Berbak (Asian Wetland Bureau, 1992).

It should also be noted Berbak was nominated as Indonesia's first site to be listed under the Convention on Wetlands of International Importance (Ramsar Convention) by Presidential Decree No. 48 of 1991 (Silvius and Giesen, 1992). This was also the first site to be so protected by an ASEAN country (Asian Wetland Bureau, 1992 citing UNESCO, 1992).

The question of Berbak's viability, outside of the worrisome matter of poaching[1] ultimately returns to the question of habitat carrying capacity and the minimum number of tigers (of appropriate sex ratio) to maintain genetic viability. Asian Wetland Bureau (1992), estimated the tiger population to be about 60 adults (9-10 males) inside the park, on the basis of habitat composition. This number might fluctuate according to flood levels and effects from the fringe population. There are also tiger sign observations from well outside of the park boundaries (HIMBIO, 1992) and near transmigration sites (Y. Rusila pers. comm., 1992).

If indeed 300 individual tigers are needed to constitute a genetically stable population (Santiapillai *et al.*, 1985) there is a strong case for expanding present park boundaries to encompass adjacent forests including part of the existing logging concessions (Asian Wetland Bureau, 1992) and establishing the Proposed Sembilang Wildlife Reserve (See following section). There are other reasons to revise the boundaries of the park. Many land use and jurisdictional boundaries in the eastern coastal plain "make little ecological sense" because they cut through peat domes and rivers draining these areas. The area is actually a vast peatswamp ecosystem, analogous to a sponge and "it is not possible to drain only half a peat dome" (Silvius and Giesen, 1992). If a peat dome is bisected by partial conversion severe effects result from the drainage, including ultimately the degradation of life support functions and biodiversity (Silvius and Giesen, 1992; Asian Wetland Bureau, 1992). Tiger numbers would no doubt suffer from such results. A clear example of land use boundaries not coinciding with hydrological realities is found in the forest concessions to the west of Berbak National Park. The far western concession is conversion forest and it sits astride peat domes. Clearing and cultivating here will "eventually destroy the economic potential of the adjacent production forest and in addition would likely have a strong negative impact on the National Park" (Silvius and Giesen, 1992) and therefore its wildlife. "It is therefore crucial to the

[1] An average of 1 tiger has been killed in the vicinity of Berbak each year for the past eight years according to one PHPA staff member and 3 tigers are known to have been poached in 1991 (Asian Wetland Bureau, 1992).

longterm survival of Berbak" that the western forest areas encompassing the catchment of its major rivers, remain intact and that no drainage in this area be undertaken (Asian Wetland Bureau, 1992). Such activity would also be in serious conflict with the spirit of the Ramsar Convention on Wetlands of International Importance as regards the conservation values of Berbak. The status of this conversion forest concession should be changed to production forest.[1] In fact production forest can act as a buffer zone to ameliorate the effects of agricultural encroachments and buffer zones also provide habitat extension to the home range of animals like the tiger (Silvius and Giesen, 1992). Furthermore, incorporation of a production forest buffer zone as a part of a protected area under Ramsar would not necessarily be in conflict with the Convention (M. Silvius pers. comm., 1992). And in the case of the tiger, density might actually increase as prey species (pigs, deer) are attracted to more open habitats provided the opening does not promote increased poaching (Santiapillai and Suprahman, 1984).

5. Sembilang Proposed Nature Reserve

To the south of Berbak in South Sumatra province lies an area which has been proposed as the Sembilang Nature Reserve (Danielsen and Verheugt, 1990). Figures 3 and 4 show the approximate inland boundary of the proposed reserve and its position with respect to Berbak, while the latter figure depicts the basic condition of forest cover of both areas. The Sembilang area has seen some initiatives to establish various protected areas (Silvius, 1986; Silvius, *et al.*, 1986.; FAO, 1982) but they were never actually incorporated in the protected areas system (Danielsen and Verheugt, 1990).

Establishment of the Sembilang proposed reserve offers the same advantages of home range extension to the main tiger population in Berbak. Through interviews and observations Danielsen and Verheugt (1990), contrary to current thought, reached the conclusion that not only does the tiger occur "throughout the coastal region of South Sumatra where there are large enough areas of suitable habitat", but enjoys the greatest density (in South Sumatra Province) just south of Berbak across the Benu River. The lowland mammal and avian fauna are rich in South Sumatra (Danielsen and Verheugt, 1990). And as with Berbak, the integration of production forests as buffer zone behind the proposed reserve would not be incompatible with their status and would actually be of benefit to the tiger by buffering encroachments and securing larger home range territory and increasing prey species density through moderate habitat disturbance.

[1] Recent discussions with BAPEDA-Jambi (prov. planning office) and KANWIL Kehutanan-Jambi (prov. forestry office) resulted in tentative, and as yet, unofficial plans to revise the status of this area from conversion to production forest, and to expand the National Park with an area of selectively logged production forest (M. Silvius pers. comm., 1992).

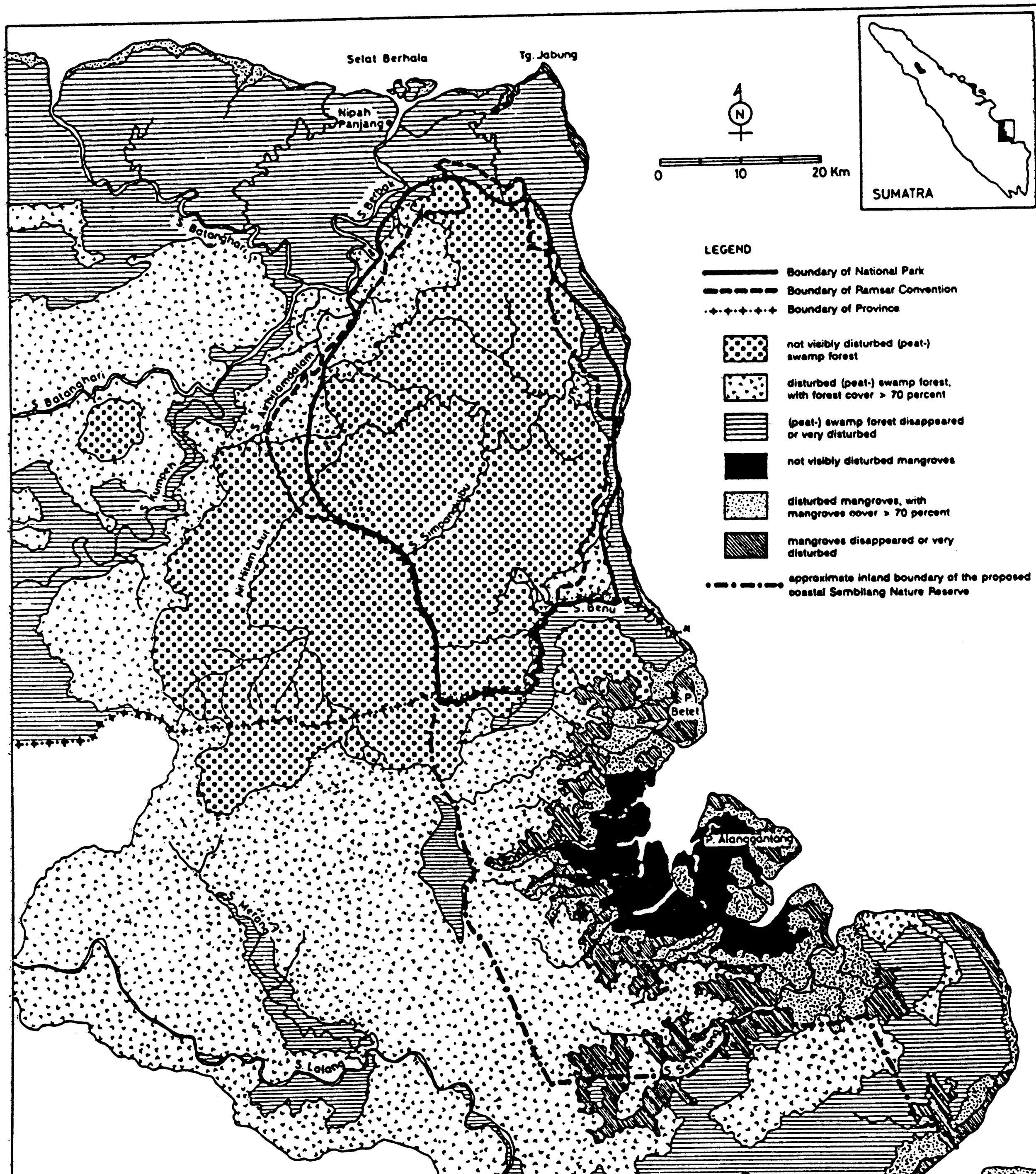


Figure 4. Condition of forest cover of Berbak National Park and surrounding areas, and its location in relation to the proposed Sembilang Nature Reserve.

Tiger evidence (Figure 3) has been seen in the large expanses of undisturbed mangrove and other areas found in the region of the Sembilang River (Danielsen and Verheugt, 1990) and human population density is very low and restricted to small fishery settlements at the estuaries of several of the regions smaller rivers (M. Silvius pers. comm., 1992). The mangrove forest reaches inland 35km making this the broadest zone of mangroves anywhere in western Indonesia (Danielsen and Verheugt, 1990), another argument for adding it to the proposed reserve system. In addition, while Berbak and Sembilang share many values, mangrove areas just to the east of Berbak are severely degraded (Asian Wetland Bureau, 1992).

6. Conclusion

For a realistic and rational approach to conserving certainly one of the last major populations of *Panthera tigris sumatrae*, as well as accruing many other integrated land use benefits, these general recommendations based on Asian Wetland Bureau (1992) are offered:

- Establish the Proposed Sembilang Wildlife Reserve as proposed by Danielsen and Verheugt (1990) or make it a part of Berbak National Park. In securing the best possible example the original swamp habitats of the lowlands of Sumatra (Asian Wetland Bureau, 1992), this would also greatly expand the protected territory of the Sumatran tiger, thereby greatly increasing the chances of survival of the sub species.

- Expand the western boundaries of Berbak National Park and the proposed Sembilang reserve to include certain logging concessions in the region and watersheds of rivers important to the ecological integrity of these protected areas. Manage areas outside the western park border as integrated buffer zones compatible with both protection forest or production forest and National Park values. This would have the effect of greatly increasing the home range territory for the tiger as well as provide other benefits such as preserving the fragile hydrological integrity of peat domes in the area.

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APPENDIX I

About *Wetland Data Base*

Wetland Data Base (WDB) has been developed under a cooperative arrangement between the Directorate General of Forest Protection and Nature Conservation (PHPA) of the Indonesian Ministry of Forestry and Asian Wetland Bureau - Indonesia (AWB). WDB is a user-friendly bilingual (*bahasa* Indonesia/English) data base specially designed for the management of wetlands in Indonesia. It stores and retrieves information on those aspects of wetland environments which are most important to consider for sustainable management. These include:

- the location of wetlands
- conservation status of these areas
- land ownership
- the values of wetlands
- habitat types
- **animal and plant species**
- existing and proposed land uses
- the impacts of activities in wetlands

WDB branches have been established at PHPA offices in Bogor and Jakarta, and at the national planning agency BAPPENAS in Jakarta.

APPENDIX II. *WETLAND DATA BASE* TIGER RECORDS - Preliminary Data (Asian Wetland Bureau)

REC.	SITE	YEAR	#	TYPE	EVIDENCE	VALID	HABITAT	REMARKS
1	SUM04	1991	1	O,I	T,OV	Y	Coastal dryland woodland	+Memo
2	SUM04	1991	1	O	OTC	Y	Lake shoreline, non-aquatic trees/shrubs	+Memo
3	SUM09	1987	-	L	?	U		
4	SUM17	1987	-	L	?	U		
5	SUM17	1991	-	I	?	U	Peat swamp forest	+Memo
6	SUM17	1992	-	I	O?T?	U		+Memo
7	SUM19	1987	-	L	?	U		
8	SUM23	1987	-	L	?	U		
9	SUM23	1992	-	O,I	B,OTV	Y		+Memo
10	SUM28	1987	-	L	?	U		
11	SUM29	1987	-	L	?	U		
12	SUM31	1981	-	L	?	Y		
13	SUM31	1987	-	L	?	Y		+Memo
14	SUM31	1991	12	L,I	?,O?T?	Y	Topogenous peat swamp woodland	+Memo
15	SUM32	1987	-	L	?	U		
16	SUM38	1981	-	L	?	Y		
17	SUM38	1983	1	O	T	Y	Marine or Estuarine Nipa woodland, flooded daily	+Memo
18	SUM38	1983	2	O	OTV	Y	Riverine forest	+Memo
19	SUM38	1983	2	O	T	Y	Non-peat Swamp forest	+Memo
20	SUM38	1983	2	O	T	Y	Non-peat Swamp forest	+Memo
21	SUM38	1984	-	O	?	Y		+Memo
22	SUM38	1991	3	O	T	Y	Peat Swamp forest	+Memo
23	SUM38	1991	2	O,I	T,O	Y		+Memo
24	SUM38	1991	2	O	TC	Y	Riverine	+Memo
25	SUM38	1991	3	I	O	U	Freshwater Swamp Thicket edge	+Memo
26	SUM38	1991	1	O,I	T,O	Y	Cultivated, former Peat Swamp forest	+Memo +Memo
27	SUM38	1991	1	I	T	Y	Perennial Riverine	+Memo
28	SUM38	1992	-	OI	?	Y		+Memo
29	SUM40	1984	-	LI	O?	Y		+Memo

APPENDIX II. *WETLAND DATA BASE* TIGER RECORDS - Preliminary Data (Asian Wetland Bureau) cont.

REC.	**SITE**	**YEAR**	**#**	**TYPE**	**EVIDENCE**	**VALID**	**HABITAT**	**REMARKS**
30	SUM40	1985	1	O	S	Y	Dryland thicket associated with freshwater wetland	+Memo
31	SUM40	1985	2	O	T	Y	Forested Hillocks associated with freshwater wetland	+Memo
32	SUM40	1985	1	O	T	Y	Riverine forest	+Memo
33	SUM40	1987	-	L	?	U		
34	SUM45	1987	-	L	?	U		
35	SUM46	1985	2	O	T	Y	Riverine (canal) grassland	+Memo
36	SUM46	1985	1	O	T	Y	Open peat swamp/macaranga scrub	+Memo
37	SUM47	1990	-	I	?	U	Seasonally flooded (unknown tidal), (non-peat) swamp, grasses	+Memo
38	SUM48	1987	-	L	?	U		+Memo
39	SUM51	1984	-	O	?	C		+Memo
40	SUM51	1987	-	L	?	C		
41	SUM65	1990	2	I	O	U		+Memo

KEY

B = BODY PARTS
C = CLAW MARKS
I = LOCAL INFORMANT
L = COMPILED LIST (SECONDARY SOURCE(s))
O = OBSERVED/VISUAL OBSERVATION OF TIGER
S = SCRAPINGS
T = TRACK(S)
U = UNCONFIRMED/UNKNOWN
V = VOCALIZATION
Y = (CONSIDERED) VALID
# = NUMBER OF TIGERS OBSERVED OR DEDUCED FROM EVIDENCE
, = (Comma) in the TYPE and EVIDENCE columns to be interpreted as "respectively".
+MEMO = A memo for this record is included in *Wetland Data Base*.

APPENDIX II. *WETLAND DATA BASE* TIGER SITES & SOURCES - Preliminary Data (Asian Wetland Bureau)

REC.	SITE	NAME	DATE*	SOURCE
1	SUM04	Blok Kluet, T.N. Gunung Leuser	08/1991	Rusila, Y. and Enis Widjanarti H. Survey Pendahuluan Areal lahan basah di Taman Nasional Gunung Leuser Blok Kluet, Aceh Selatan.
2	[as above]			
3	SUM09	Dolok Sembelin	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol.II.
4	SUM17	Giam-Siak Kecil	1987	[as above]
5	SUM17	Giam-Siak Kecil	11/1991	Giesen, W. and B. van Balen. The Wetlands of Giam-Siak Kecil Wildlife Reserve, Riau, Sumatra. FINAL DRAFT REVIEW COPY ONLY.
6	SUM17	Giam-Siak Kecil	09/1992	Martin, Keith. (pers comm)
7	SUM19	Danau Bawah and Pulau Besar	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol. II.
8	SUM23	Kerumutan Baru	1987	[as above]
9	SUM23	Kerumutan Baru	09/1992	Martin, Keith. (pers comm)
10	SUM28	Rimbo Panti	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol. II.
11	SUM29	Danau Maninjau Utara / Selatan	1987	[as above]

* The date of fieldwork/observation is used if known; otherwise, the date of publication listed.

APPENDIX II. *WETLAND DATA BASE* TIGER SITES & SOURCES - Preliminary Data (Asian Wetland Bureau)

REC.	**SITE**	**NAME**	**DATE***	**SOURCE**
12	SUM31	Kerinci Seblat	1981	de Wulf, Robert, Djoko Supomo and Kurnia Rauf. Kerinci-Seblat Proposed National Park. Preliminary Management Plan. 1982-1987. FAO.
13	SUM31	Kerinci Seblat	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol II.
14	SUM31	Kerinci Seblat	04/1991	Giesen, Wim and Sukotjo. Lake Kerinci and the Wetlands of Kerinci Seblat National Park, Sumatra. FINAL DRAFT REVIEW COPY ONLY.
15	SUM32	Lunang	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol. II.
16	SUM38	Taman Nasional Berbak	1981	de Wulf, Robert, Djoko Supomo and Kurnia Rauf. Berbak Game Reserve: Management Plan 1982-1987. FAO Field Report 38.
17	SUM38	Taman Nasional Berbak	11/1983	Silvius, Marcel J. and Wim J. M. Verheugt. Soils, Vegetation, Fauna and Nature Conservation of the Berbak Game Reserve, Sumatra, Indonesia.
18	[as above]			
19	[as above]			
20	[as above]			
21	SUM38	Taman Nasional Berbak	02/1984	Blouch, R.A. Current Status of The Sumatran Rhino and Other Large Mammals in Southern Sumatra. IUCN/WWF.

* The date of fieldwork/observation is used if known; otherwise, the date of publication listed.

APPENDIX II. *WETLAND DATA BASE* TIGER SITES & SOURCES - Preliminary Data (Asian Wetland Bureau)

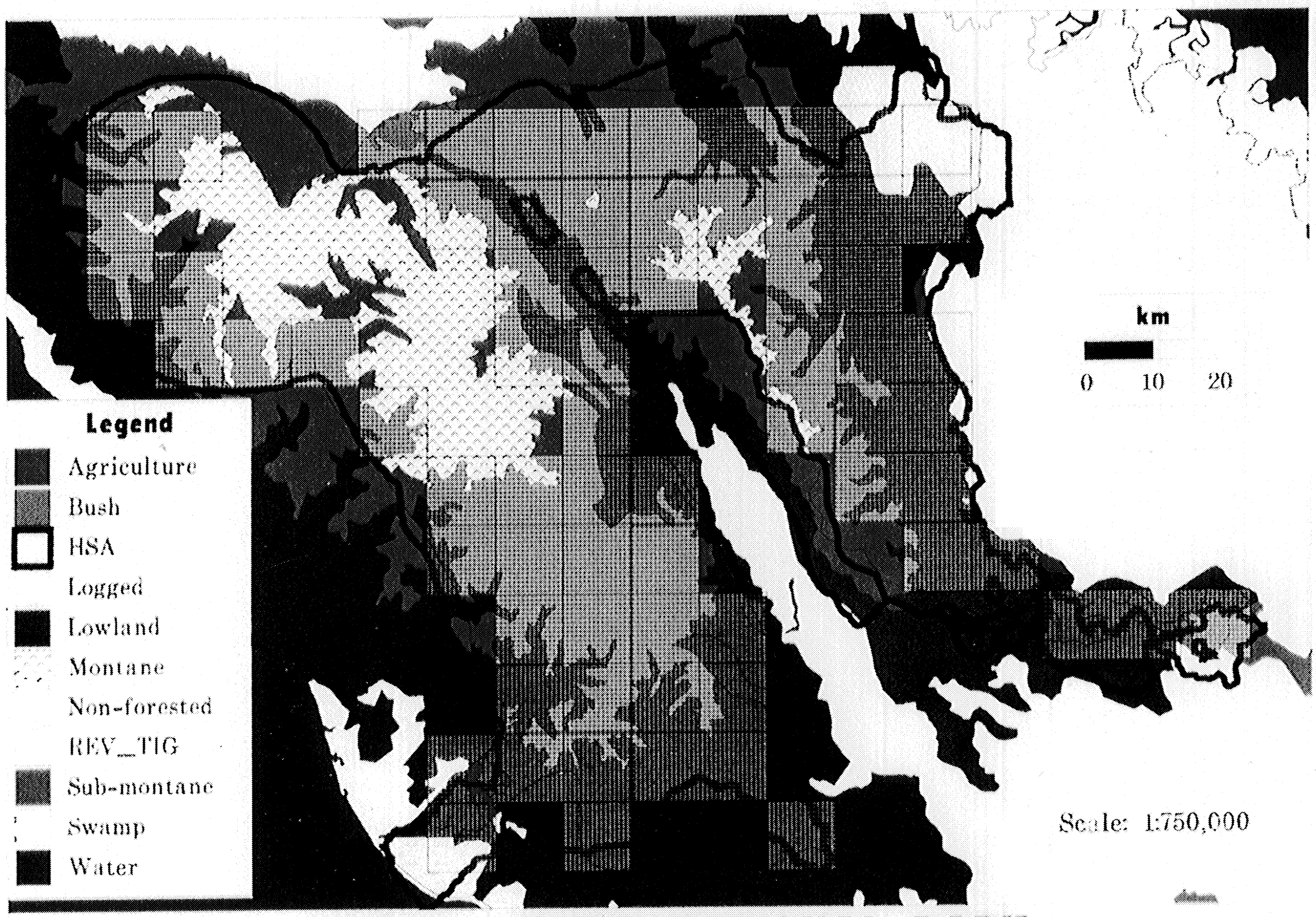
REC.	SITE	NAME	DATE*	SOURCE
22	SUM38	Taman Nasional Berbak	08/1991	HIMBIO (1992)
23	[as above]			
24	[as above]			
25	[as above]			
26	SUM38	Taman Nasional Berbak	09/1991	Rusila, Y. (Pers comm 1992)
27	[as above]			
28	SUM38	Taman Nasional Berbak	01/1992	Zech, Ben (pers comm)
29	SUM40	Bukit Gedang Seblat	1984	Santiapillai, C. and Hayani Suprahman., A Preliminary Report on the Bukit Kayu Embun and Bukit gedang Seblat Game Reserves in Southern Sumatra in the Province of Bengkulu: Problems and Prospects., IUCN/WWF.
30	SUM40	Bukit Gedang Seblat	1985	Santiapillai, C. and Hayani Suprahman., Elephants and Tigers: Their distribution and depredation in the northern part of Bengkulu province in Sumatra. WWF/IUCN.
31	[as above]			
32	[as above]			

* The date of fieldwork/observation is used if known; otherwise, the date of publication listed.

APPENDIX II. *WETLAND DATA BASE* TIGER SITES & SOURCES - Preliminary Data (Asian Wetland Bureau)

REC.	**SITE**	**NAME**	**DATE***	**SOURCE**
33	SUM40	Bukit Gedang Seblat	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol. II.
34	SUM45	Banyuasin Musi River Delta	1987	[as above]
35	SUM46	Padang Sugihan	10/1985	Nash, S.V. and A.D. Nash. The Large Carnivores, Primates, and Ungulates in the Padang-Sugihan Wildlife Reserve, South Sumatra. WWF/IUCN.
36	[as above]			
37	SUM47	Ogan-Komering and Lebaks	08/1990	Giesen, W. and Sukotjo. Conservation and Management of the Ogan-Komering and Lebaks South Sumatra. FINAL DRAFT REVIEW COPY ONLY.
38	SUM48	Taman Nasional Sumatra Selatan I	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol. II.
39	SUM51	Way Kambas	1984	Blouch, R.A. Current Status of The Sumatran Rhino and Other Large Mammals in Southern Sumatra. IUCN/WWF.
40	SUM51	Way Kambas	1987	Silvius *et al*. The Indonesian Wetland Inventory. A Preliminary Compilation of Information on Wetlands of Indonesia. Vol. II.
41	SUM65	Lematang River Peatswamps	08/1990	Giesen, W. and Sukotjo. Lematang River Peatswamps South Sumatra. FINAL DRAFT REVIEW COPY ONLY.

* The date of fieldwork/observation is used if known; otherwise, the date of publication listed.



GUNUNG LEUSER NATIONAL PARK

Sumatran tiger distribution - revised distribution