Perhimpunan Kebun Binatang Se Indonesia
Republik di Indonesia

Masterplan Harimau Sumatera Indonesia

Panthera tigris sumatrae

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Perhimpunan Kebun Binatang Se Indonesia
Republic di Indonesia

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Ronald Tilson, Minnesota Zoo/Sumatran Tiger Project; Kathy Traylor-Holzer, Minnesota Zoo; Gerald Brady, Potter Park Zoo

Tigers in Crisis

The Sumatran tiger (*Panthera tigris sumatrae*), one of the rarest species in Indonesia, is considered critically threatened by the World Conservation Union (IUCN) (Nowell and Jackson, 1996). A century ago, tens of thousands of tigers roamed the islands of Bali, Java and Sumatra. By the late 1930s the Bali tiger (*P.t. balaica*) was driven to extinction, followed by the Javan tiger (*P.t. sondaica*) in the 1970s (Seidensticker, 1987). Of Indonesia's tigers only the Sumatran tiger remains today, its wild population limited to approximately 400 individuals living in five national parks and two game reserves and another 100 tigers possibly surviving in unprotected forest fragments (Tilson et al., 1994).

Before 1990 the status, distribution and threats of the wild Sumatran tiger population were largely unknown (Borner, 1978). Levels of poaching and habitat fragmentation were uncertain, as were their effects on the tiger population. "Problem" tigers, those that attack livestock or humans, were typically killed or captured and transported to the nearest zoo with no consideration of the effect on either the wild or captive population. At that time the world's population of about 180 known captive Sumatran tigers was being managed primarily by two regional zoo programs in North America and Europe, with a few tigers in Australasia. The Indonesian Zoological Parks Association (PKBSI) had not yet developed any cooperative programs for its endangered species, and there was virtually no information available on their captive tigers. Tigers were living in overcrowded and poorly designed facilities. Neonatal mortality rates were high, and no genetic management for breeding was in place. Most tigers were not registered in the *International Tiger Studbook* (Seifert and Müller, 1989), and wild-caught tigers were not optimally utilized, even though new genetic founders were greatly needed outside of Indonesia. There was no plan for wild Sumatran tigers other than the same one that led to the demise of the Javan tiger.

The precarious status of the Sumatran tiger in the wild and its mismanagement in captivity called for immediate action in Indonesia. Initial contact with Taman Safari Indonesia (TSI) and Ragunan Zoo was made by the Tiger Species Survival Plan (SSP) of the American Zoo and Aquarium Association (AZA). Concurrently, the PKBSI was urged to develop an Indonesian zoo-based captive management program for its tiger subspecies. Preliminary goals included assessing the status of the captive tiger population, evaluating the conservation value of these tigers, and determining the types of training zoo staff needed to better manage their tigers.

At the same time and with the assistance of TSI, the AZA Tiger SSP approached the Indonesian Directorate General of Forest Protection and Nature Conservation (PHPA) on how to assess the wild population and develop an effective management strategy. From the subsequent workshops and programs, an innovative partnership evolved among Indonesian zoos (PKBSI), forestry

(PHPA) and international conservation authorities (IUCN) involved with tiger conservation in Indonesia. In five years time, Indonesia has put in place well-developed *ex situ* and *in situ* programs linked by a national conservation strategy for the subspecies. The projects and processes outlined here describe the process and have served as a model demonstrating how to link the resources and unique strengths of zoo and field conservation authorities to develop effective conservation management programs for endangered species (see Tilson and Christie, in press; and Table 1). Since development of the Sumatran tiger program, similar workshops and programs have been initiated in Indonesia for Asian elephants, Sumatran rhinos, white-winged wood ducks, orangutans, Javan gibbons, Javan hawk- eagles, Komodo monitors and sea turtles.

Development of Indonesia's Captive Management Program

Initial Stages

At the joint meeting of the IUCN/SSC Conservation Breeding Specialist Group, IUCN/SSC Cat Specialist Group, and the AZA Felid Taxon Advisory Group (Front Royal, VA, May 1991), the Sumatran tiger was listed as "critical" based on the Mace-Lande criteria of threat. Habitat loss, decreasing prey populations, and increasing poaching were recognized as the major threats, and a Population and Habitat Viability Analysis (PHVA) was highly recommended for this taxon to assess the viability of the remaining wild populations.

At the same time, the Indonesian zoo community recognized that the Sumatran tiger needed a captive management strategy. In general, holding facilities for tigers were too overcrowded, individual tigers were confined in spaces too small, and no maternity dens for pregnant females were available. Reproduction occurred among their tigers, but neonatal deaths were high. Medical immobilizations, immunizations and examinations were not performed regularly. Why? Lack of drugs, equipment and experience. Individual tigers were not identified with tattoos or transponders. Medical and management records were poorly kept. Problem wild Sumatran tigers caught by the Indonesian Department of Forest Protection and Nature Conservation (PHPA) were transported to the nearest zoo with no forethought on how best to incorporate these wild-caught founders into a coordinated regional tiger program. It was clear that improvements were necessary.

In late 1991 Ulysses Seal (CBSG Chairman), Ronald Tilson (Minnesota Zoo) and Jansen Manansang (Taman Safari Indonesia) discussed these problems. Jansen took the initiative by finding support within the PKBSI and PHPA and planning a workshop to resolve these issues within Indonesia. We also realized the need for a tiger facility before this program could move forward. Ross Taylor and Nicholas Reindl (Minnesota Zoo), both of whom have 20 years managing Siberian tigers, participated in a group effort to design a facility adapted to the climate of Indonesia that would meet the long-term needs of the Indonesia Sumatran tiger program.

Gerald Brady, AZA Sumatran Tiger Subspecies Coordinator (Potter Park Zoo) took responsibility to request zoos participating in the Sumatran Tiger SSP program to assist with this program (eventually 18 North American zoos contributed funds). Matching funds to Taman Safari Indonesia's costs (50% each) were raised to construct the tiger breeding facility. Additional costs for the workshop were provided by TSI and the Minnesota Zoo. Ligaya

Tumbelaka (TSI and Bogor Agriculture University) was identified as the studbook keeper and the process was underway. Within a few days the Regional Studbook was compiled, and at the workshop, details for individual tigers were clarified by the various attending zoo directors and veterinarians.

A newspaper article from the *Jakarta Times* reported on the workshop (see Box 1). It is one of more than a dozen articles that applauded Indonesia's initiative to develop a comprehensive management strategy for one of its most threatened species. This transfer of knowledge and technology that empowers range countries to manage their own programs is the most powerful contribution the Tiger SSP can make to the conservation of tigers globally. The final product of this workshop also meets the goals of the *Tiger Global Conservation Strategy* (GCS), which are to develop captive breeding programs in regions of origin and to encourage these range states to concentrate their programs on their endemic subspecies (in this case, *Panthera tigris sumatrae*). The Indonesian Regional Sumatran Tiger Program can now be integrated with other Regional Programs on a global level through the *Tiger GCS* to maximize the security of this subspecies.

Captive Management Workshop

A preliminary training and masterplanning workshop was held in November 1992 at Taman Safari Indonesia in concert with the dedication of this new facility. Directors, veterinarians and animal management staff from ten PKBSI zoos were invited to a three-day workshop to initiate the development of a cooperative management program for tigers. A team of tiger managers from North America and Europe addressed veterinary, studbook, husbandry, reproductive and management issues. Animal records were collected prior to and during the workshop to extensively update the studbook data and to establish a regional Sumatran tiger studbook for Indonesia. Husbandry issues were discussed, and key portions of the Tiger SSP's husbandry manual were adapted and translated into Indonesian. Tiger immobilizations were demonstrated as well as the collection and cryopreservation of sperm. The purpose of the meeting was to provide PKBSI with a perspective on how to manage a regional tiger program within Indonesia and to provide zoo staff with the data management skills necessary to develop and manage their tiger masterplan. By the end of the meeting a PKBSI Sumatran tiger management committee was formed, two co-coordinators elected, and a studbook keeper appointed, formalizing PKBSI's commitment to work cooperatively (see Tilson et al., 1996b for more details).

Training and Evaluation

It was evident, however, that more extensive staff training was needed and that PKBSI tigers, facilities and management procedures needed to be evaluated at each and every zoo. This became apparent when we asked how many zoos routinely immobilized and medically evaluated their tigers. Not a hand was raised -- not a single tiger had ever been given a routine physical examination. Funding was secured from the AZA Ralston Purina Big Cat Survival Fund for a team of AZA advisors (joined by Australian and European colleagues) to return to Indonesia and visit seven zoos in Java in 1994, and four zoos in Java and two zoos in Sumatra in 1995. Specific goals were to: verify animal records and identities; provide basic training to zoo staff in daily tiger management and preventive health care; perform tiger health physicals; evaluate physical facilities for tigers; initiate a blood serum bank, molecular DNA library, and genome resource bank for tigers; repair fractured canine teeth of genetically valuable tigers; and train Indonesian zoo counterparts to perform these tasks themselves. This transfer of information,

Safari Park starts program to breed tigers in captivity

CISARUA, West Java (JP): The first Sumatran tiger captive breeding facility was opened yesterday at the Indonesian Safari Park in Cisarua, West Java, some 80 kilometers southeast of here.

Funding was provided by 18 foreign zoos, including the Memphis, Phoenix and Minnesota zoos in the United States.

The facility, which can accommodate 15 tigers, consists of 10 single pens measuring 5 x 5 meters, two dens, two rooms where tigers can give birth and two spacious rooms for breeding. Each pen is provided with platforms for resting and scratching posts.

Director of the park Jansen Manansang told *The Jakarta Post* that almost 90 percent of the funds for thte Rp 100 million tiger breeding facility was provided by the foreign zoos. He siad three males and one female from North Sumatra and Jambi of the park's population of 10 tigers were kept in the cage at present. "But we plan to put more tigers in for breeding."

Manasang said the park was considered an ideal site for the tiger-breeding program because of its rural location and its fine facilities. The park has a collection of around 800 animals of 300 species.

The Sumatran tiger (*Panthera tigris sumatrae*) is endemic to the island of Sumatra and is a solitary anmals. The female tiger nurtures its cubs for 14 months until the offspring can fend for themselves. The animals are sexually mature at two to three years of age.

Widodo Sukohadi Ramono, chief of the species conservation section at the Directorate General of Forest Protection and Nature Conservation (PHPA), said a 1984 census determined there were around 600 Sumatran tigers surviving in the wild. "But we believe the number has been reduced to 400."

Forest conversion, farming, poaching and resettlement projects have all contributed to the decrease in the tiger's population, according to Widodo.

Problems

Komar Soemarna, Director General of Nature Conservation at the PHPA, told the *Post* that breeding an animal in captivity was fraught with problems. "We have to know its biology, behavior and also the habitat changes which occur in captivity."

Soemarna said the government's conviction to breed the tiger had been hampered by the lack of knowledge about its habits. "But we are truly behind the conservation of the animal."

He said the participation of foreign zoos in funding the facility showed their concern about the plight of the animals. Seventy Sumatran tigers are found at a number of zoos all over the world, he said.

He said the captive breeding would not lead to a trade in the tigers because Indonesia had signed the Convention on International Trade of Endangered Species of Wild Fauna and Flora.

D. Ashari, chairman of the Indonesian Zoological Parks Association told the *Post* that Indonesians should be more educated about the importance of nature conservation to ensure that animal species will be extant for future generations.

"One thousand of an animal species population means that it is in danger," he said. "But Indonesians think there are still many of them and do not realize the danger until the animal is extinct."

Earlier the same day, a three-day workshop on Regional Sumatran Tiger Captive Breeding opened in Cisarua. The workshop, with 28 local and overseas participants, has as one item on its agenda the formulation of a regional Suamtran tiger conservation master plan.

Among the seminar's sponsors are the American Association of Zoological Parks and Aquaria, the Indonesian Zoological Parks Association and the Directorate General of Forest Protection and Nature Conservation.

technology, and expertise is a priority of the IUCN CBSG *Tiger Global Conservation Strategy* (Tilson et al., 1993), and serves an integral role in empowering the Indonesians to develop their own management program.

During the project, the team visited nine of ten Indonesian zoos:

- Taman Safari Indonesia at Bogor
- Kebun Binatang Ragunan in Jakarta
- Gembira Loka in Yogyakarta
- Kebun Binatang Bandung in Bandung
- Satwa Taru Surkarta in Solo
- Timjomoyo in Semarang
- Kebun Binatang Surabaya in Surabaya
- Griya Satwa Mulya in Medan, Sumatra
- Kebun Binatang Jambi in Jambi, Sumatra

The tenth zoo, Kebun Binatang Bukittinggi in Bukittinggi, Sumatra had no tigers at that time and therefore was not visited. Fifty-one tigers (over 90%) in the Indonesian PKBSI program were medically evaluated and permanently identified with tattoos and transponders; only very old tigers or young cubs were not immobilized. Skin biopsies, hair samples, blood serum, and sperm were collected and are now cryopreserved in a genome resource bank at Taman Safari Indonesia. Physical facilities for tigers, animal management procedures and policies, diets, and daily record keeping were evaluated. About 150 Indonesian zoo staff were provided hands-on training that focused on proper procedures for tiger husbandry, record-keeping, health and reproductive management (see Tilson et al., 1996b for a complete review).

At the conclusion of each of these 2-3 week visits to Indonesian zoos, a two-day meeting of the PKBSI Sumatran Tiger management committee was held at Taman Safari Indonesia to discuss results, consider recommendations, and decide how to implement them. At the 1995 meeting the PKBSI, PHPA and CBSG signed a Memorandum of Cooperation indicating everyone's willingness to work together to develop a global Genome Resource Banking Action Plan for tigers (Wildt et al., 1995; Byers, Chapter 3). The PKBSI was also presented with a tiger immobilization "rescue" kit and transport crate for use in capturing and transferring problem tigers to the new tiger facility.

Animal Records and Verification

While visiting the PKBSI zoos, we became aware of animal identification and origin issues questioning the conservation value of a number of tigers and precluding completion of the masterplan. Only six founders had official PHPA documentation regarding their capture date and site; the remaining eight living founders (as well as six dead founders) needed verification. During interviews we discovered that zoo staff did not know or recorded incorrectly the identity of some parents, sometimes paired an estrous female with more than one male, and were confused as to which tigers had been sent to North America as part of the AZA Tiger SSP. In addition, zoo personnel admitted that other tiger subspecies had been introduced into the Sumatran tiger line. Subsequent molecular DNA analysis confirmed all managed tigers as Sumatran (Wentzel et al., in press), although some parentage issues still remain. None of these issues would have been brought to air without direct on-site visits of each zoo. This also

demonstrates the critical need for an accurate record-keeping system and animal identification procedures.

Breeding Facility

Preliminary discussions suggested the need for a captive management facility for tigers to serve as the official repository for wild-caught tigers (including "problem" tigers) from Sumatra. This would establish a link between *ex situ* and *in situ* programs in that wild tigers would be sent directly to the facility by PHPA, quarantined, medically evaluated, and permanently identified with a tattoo and transponder. Blood serum could be collected to determine viruses present in wild population, skin biopsies taken for DNA analysis, and sperm collected and cryopreserved for a genome resource bank.

Because the Indonesian government had already designated Taman Safari Indonesia (TSI) as the Center for the Reproduction of Endangered Wildlife in Indonesia, it was viewed as the most appropriate site. A tiger facility was designed by TSI and Minnesota Zoo tiger management staff, and donations from 18 AZA Tiger SSP zoos funded the materials for the construction (TSI contributed the labor). The 15m x 21m facility is large enough to maintain four or more breeding pairs of tigers, each provided with an indoor and an outdoor area, and includes two enclosed maternity dens. Wild-caught tigers can either be bred at this facility or directly transferred after quarantine to other PKBSI zoos, facilitating their integration into a managed breeding program. The intent for this facility was to serve a "pass through" function, not to be a permanent or long-term holding facility. Unfortunately, our expectations of transferring tigers quickly to other zoos have not materialized.

Sumatran Tiger Masterplan

Completion of the molecular DNA analysis and examination of PHPA records allowed the verification of most of the tigers in the PKBSI program and completion of the masterplan in April 1997. A majority of the wild-caught founders had not yet reproduced, while other founders were overrepresented and their descendants progressively inbred. The PBKSI management committee formed their first round of breeding recommendations in order to equalize founder representation and reduce inbreeding. Reactions to inter-institutional transfers were tentative, both within Indonesia and exports out of Indonesia, so final decisions were deferred until November 1997 when the committee will review the outcome of the agreed breeding recommendations and address additional transfers. To facilitate tiger transfers, a transport crate and immobilization equipment were donated to the PKBSI program, as well as financial support for transport costs.

Conservation of Wild Tiger Populations

Concurrent with the development of the PKBSI tiger program, efforts to address the management of wild Sumatran tiger populations began. In Indonesia, PHPA in the Ministry of Forestry is the government agency in charge of national parks and other protected areas. All wild animals living in Indonesia are protected under the 1982 Wildlife Protection Law and are considered the property of PHPA, including those in captivity. PHPA therefore was involved with the development of the PKBSI tiger captive management program from the start, and PHPA staff fully participated in every PKBSI tiger meeting.

Sumatran Tiger PHVA Workshop

As discussions began between the AZA Tiger SSP and PKBSI regarding the Indonesian captive tiger program, initial contacts were also made with appropriate PHPA staff in Forest Protection and Nature Conservation. These discussions led to a formal invitation for the IUCN Conservation Breeding Specialist Group to conduct a Population and Habitat Viability Assessment (PHVA) for the Sumatran tiger. Preliminary data on the distribution of tigers and their available habitat was collected directly from forestry staff prior to the workshop to allow the development of working maps using a Geographic Information System (GIS).

In November 1992, directly following the first PKBSI tiger meeting, a PHVA workshop was convened in Padang, Sumatra to gather and assess information about the distribution, status and threats to the remaining wild Sumatran tigers. The results suggested that as few as 400 Sumatran tigers survive in five national parks and two game reserves, and another 100 tigers possibly survive in unprotected forest fragments (Tilson et al., 1994). Population viability analysis estimated the repercussions of even low levels of poaching and removal of problem animals on the estimated small isolated populations. In response to the decline of wild tiger populations PHPA recommended a set of short-term and long-term goals for wild tigers (Soemarna et al., 1994) but recognized the need for a more extensive, comprehensive management strategy.

Indonesian Sumatran Tiger Conservation Strategy

Recommendations from zoo and field conservation experts were formulated into the *Indonesian Sumatran Tiger Conservation Strategy*, published in 1994 by the Ministry of Forestry, to establish priorities for the conservation of wild and captive tigers in Indonesia. The *Conservation Strategy* outlines four general priorities to promote the long-term survival of Sumatran tigers:

- secure and protect remaining tiger populations and their habitat;
- develop conservation management goals and intervention strategies for the remaining wild Sumatran tiger populations;
- develop a Sumatran tiger captive management program for the reinforcement and recovery of wild populations; and
- establish a communication and infrastructure network that is responsible for the survival of Sumatran tigers in Indonesia, accountable to PHPA, national and international conservation agencies, NGOs and the Indonesian public.

This conservation strategy, now available in both English and Indonesian, provides the guidelines for the development of new and existing conservation and management programs for wild Sumatran tiger populations, and also recognizes and supports the development of a strong *ex situ* tiger program in Indonesia (Ministry of Forestry, 1994).

To implement specific recommendations outlined in the *Strategy*, PHPA, Taman Safari Indonesia, and the CBSG Tiger Global Conservation Strategy (GCS) initiated the Sumatran Tiger Project (STP) in 1995. Funded by the *Save the Tiger Fund*, this project includes a long-term study of tiger biology and human-wildlife interactions, rapid evaluations of tigers and their habitat across Sumatra, community-based conservation efforts to reduce human-tiger conflicts, and improvement of existing programs to protect remaining tiger habitats (see Tilson et al., 1996a for details).

Linking Ex Situ and In Situ Conservation

The long-range goal of the *PKBSI Masterplan Harimau Sumatera Indonesia* (Indonesian Sumatran Tiger Masterplan) is to link its activities with the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994), thus providing conservation options for PHPA to prevent the extinction of wild tigers in Sumatra (Tilson et al., 1996a). To date, these activities have included programs related to breeding, removal of problem tigers from the wild, sharing of information, training, and education and awareness programs at the village level and national level. The development of communication and a working relationship between Indonesian zoo and forestry staff over the past several years will facilitate this integration of captive and wild tiger management programs.

Problem Tiger Rescue Team

One illustrative example of how tiger conservation can benefit from linking *in situ* and *ex situ* programs is the issue of problem tigers. Problem tigers, as defined by PHPA, are tigers that leave protected forests and come into conflict with villages, usually by killing livestock or domestic animals. Officially, two people are killed on average every year by tigers in Sumatra. Recently, the number of these tragedies has increased as habitat has shrunk and human encroachment into tiger habitats has increased (Plowden and Bowles, 1997). Local villagers often leave traps, poisoned bait, or ask local law enforcement authorities to help kill these rogue animals. In response, PKBSI and PHPA, with assistance from international donors and tiger experts, are forming a tiger rescue team comprised of PKBSI veterinarians and PHPA staff. In addition, these vets provide field staff with immobilization expertise and training in proper procedures. The team's primary function is to provide rapid response, capture expertise and logistical support to remove "problem" tigers from protected areas in Sumatra before they are killed by villagers, police or the military. The result is a win-win situation for villagers and the larger conservation community: villagers gain the obvious benefit of immediate removal of these tigers, while the captive conservation community gains a valuable genetic contribution to captive programs.

Conservation and Education

The crisis facing tigers is multi-faceted, and long-term conservation efforts will not be possible without the cooperation of many different segments of society in tiger range countries and abroad. Ultimately, these changes will not be possible without a significant increase in awareness and education among many segments of society. At the level of forest-edge communities, hunting of pig and deer can decrease the availability of prey, and grass cutting and fires set to enable villagers to collect fodder for livestock can alter tiger habitat. The market for non-timber forest products is lucrative in some villages and small urban markets near forested areas. Live animals such as primates, songbirds, and even occasionally tiger cubs captured in protected forests are sold in legal and illegal markets. Ivory, rhino horns and tiger parts are sold as traditional medicines, art and amulets. These markets are frequently driven by the massive Traditional Chinese Medicine market in China and other East Asian communities around the world (Mainka and Mills, 1995).

In Indonesia, zoos are found in most major cities and are visited by millions of people. For example, during the Muslim holiday of Lebaran, Ragunan Zoo in Jakarta is visited by about 200,000 people a day for a week straight. These facilities can become important fora to convey conservation messages to the people of Indonesia. In particular, visitors can be made aware of

the link between traditional medicines made from tiger parts -- one of the major causes of declining tiger numbers across Asia -- and poaching of wild tigers. A conservation education brochure produced jointly by PHPA and PKBSI (see Appendix) was produced and distributed to the ten zoos in Sumatra and Java that have tigers. Addition education and awareness material is being produced by the Sumatran Tiger Project that will be distributed by the tiger rapid evaluation and rescue teams to government authorities and the public throughout Sumatra.

Tigers as Umbrella Species

Finally, charismatic animals such as tigers have shown that they can garner public interest and support for both *in situ* and *ex situ* programs. The tiger as an umbrella species has strong potential to improve the capacity of both the captive and field conservation communities to raise support for zoo, field and integrated programs. Historically, tigers roamed across most of Asia. By protecting habitat suitable for tigers, a broad diversity of other species which lack the charisma and public interest of tigers can be saved (Tilson, 1995).

In zoos, tigers provide a similar draw -- they remain one of the most viewed animals in many zoo collections. In Indonesia, tiger conservation programs have already begun to blur the once clearly demarcated differences between zoo and wild tiger conservation programs. The synergy created by the cooperation and mutual recognition of both types of programs has already led to powerful alliances among government agencies and local and international non-governmental organizations that would have been unthinkable just a few years ago. Today, the outlook for saving Indonesia's last remaining subspecies of tiger is much brighter than it was a decade ago -- and much of the success can be attributed to Indonesia's pioneering efforts to integrate at many levels the *in situ* and *ex situ* conservation of Sumatran tigers. These efforts can serve as a blueprint for other species conservation efforts in Indonesia, and as a model for successful linkages between zoo and field conservation communities across Asia.

Summary of the Captive Program

In 1992 the captive Sumatran tiger population in its range country was mismanaged from a conservation perspective, and its status unknown outside of Indonesia. Five years and five trips to Indonesia later, the captive population is managed by two co-coordinators, a management committee and a competent studbook keeper; an accurate studbook for population management has been established; all tigers are recorded in the *International Tiger Studbook*; most tigers have been physically examined and identified with tattoos and transponders; over 150 staff have been trained in husbandry, veterinary and reproductive procedures; a fledgling genome resource bank has been established; a tiger rescue center has been constructed; needed veterinary equipment has been provided to every zoo; and now an initial masterplan has been drafted for the cooperative management of Sumatran tigers in Indonesia.

Other highlights that were accomplished include:

- 50 of 61 tigers currently in the Indonesian PKBSI program were evaluated. All of these tigers were given physical examinations that included collecting blood for blood cell counts and serum chemistries, taking tissue biopsies for genetic evaluation, permanently tattooing each animal with a temporary or permanent studbook number, and placing a transponder

under the skin for backup identification. Six genetically valuable tigers received dental treatment.

- Physical facilities were evaluated for tigers, animal management procedures and policies, diets, and daily record keeping were evaluated for 10 PKBSI zoos and recommendations were made to the PKBSI (see Chapter 3).

- An *Indonesian Sumatran Tiger Studbook* was established, and a studbook coordinator was appointed and trained in the use of SPARKS.

- A PKBSI Genome Resource Bank was established at Taman Safari Indonesia. It now includes semen from 14 male tigers. Skin biopsies and hair samples were collected from 52 tigers to initiate a molecular DNA library (for subspecies discrimination, among other uses) at Taman Safari Indonesia. Blood serum samples were collected and banked from 54 tigers for, among other uses, screening for diseases and comparisons between wild-caught and captive-born tigers. A Memorandum of Cooperation (MOC) indicating "the PKBSI's willingness to work with CBSG to develop and complete a global Genome Resource Banking Action Plan for tigers" was signed. Signatories included representatives from the PKBSI, the IUCN/SSC CBSG, and PHPA.

- Key staff from PHPA attended the meetings and recommended that the masterplan reflect conservation priorities outlined in the 1994 *Indonesian Sumatran Tiger Conservation Strategy* [Ministry of Forestry, 1994].

The PKBSI Sumatran tiger population is now poised to significantly contribute to the conservation of Sumatran tigers through integration with other regional programs as a key component of the CBSG *Tiger Global Conservation Strategy*, and through its links with PHPA and *in situ* conservation program for wild tigers.

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Table 1. Timetable of events in the development of ex situ and in situ tiger conservation programs in Indonesia (primary funding source in parentheses).

	Ex Situ Programs	*In Situ* Programs
Summer 1992	Construction of breeding facility at TSI *(AZA Tiger SSP zoos, TSI)*	Data collection from PHPA Generation of GIS database *(Minnesota Zoo)*
November 1992	Dedication of new facility Initial workshop Training/demonstrations Regional studbook Tiger Management Committee *(Minnesota Zoo, TSI)*	PHVA workshop Update GIS database PHPA Action Plan *(AZA Ralston Purina CEF, Minnesota Zoo)*
January 1994	Training in 7 PKBSI zoos Tiger/facility evaluations Genome Resource Bank *(AZA Ralston Purina CEF, Asian Tiger Fund)*	Publication of *Indonesian Sumatran Tiger Conservation Strategy* by Indonesian Ministry of Forestry *(Minnesota Zoo)*
January 1995	Training in remaining zoos Tiger/facility evaluations Preliminary Masterplan meeting *(AZA Ralston Purina CEF)*	Donation of tiger "rescue" kit *(Australian Commonwealth EPA, ARAZPA, Zoological Parks Board of NSW)*
June 1995		Initiation of Sumatran Tiger Project *(Save the Tiger Fund)*
December 1995		Initiation of Community-Based Conservation Program *(Save the Tiger Fund, USFWS Rhino and Tiger Fund)*
June 1996	Molecular DNA analysis for subspecies verification *(AZA Ralston Purina CEF)*	
April 1997	PKBSI Tiger Masterplan *(Save the Tiger Fund, Minnesota Zoo)* Conservation education brochure *(Australian Commonwealth EPA, ARAZPA, Zool. Parks Board of NSW)*	Publication of bilingual edition of *Indonesian Sumatran Tiger Conservation Strategy (ESSO Indonesia)*
June 1997		Initiation of mobile Tiger Conservation Teams *(Zoological Society of London)*
February 1998		Formation of Sumatran Tiger Steering Committee Working group meeting at *Year of the Tiger Conference*, Dallas, TX *(Save the Tiger Fund, Sumatran Tiger Project)*

The Indonesian PKBSI Sumatran tiger program has shown enormous growth over the past five years due to the generous support of many individuals and organizations. Listed below are the primary projects and supporting agencies.

(1992) Construction of new tiger breeding facility at Taman Safari Indonesia; supported by donations from 18 Tiger Species Survival Plan (SSP) zoos of the American Zoo and Aquarium Association (AZA) and by Taman Safari Indonesia.

(1992) Sumatran Tiger Captive Breeding Workshop to establish the studbook, initiate the PKBSI Sumatran Tiger program, and discuss tiger husbandry issues; supported by Taman Safari Indonesia, IUCN/SSC Conservation Breeding Specialist Group, and the Minnesota Zoo.

(1994) Training and tiger/facility evaluations in seven PKBSI zoos and establishment of the PKBSI Tiger Genome Resource Bank; supported by the AZA Ralston Purina Conservation Endowment Fund (CEF) and the Minnesota Zoo's Asian Tiger Fund.

(1995) Completion of training and tiger/facility evaluations in PKBSI zoos and preliminary masterplan meeting; supported by the AZA Ralston Purina Conservation Endowment Fund (CEF).

(1995) Donation of a tiger rescue kit and crate; population management training for studbook keeper; production of tiger conservation education brochure; supported by the Australian Commonwealth Environmental Protection Agency, the Australasian Regional Assocation of Zoological Parks and Aquariums (ARAZPA), and the Zoological Parks Board of New South Wales).

(1997) Donation of tiger immobilization equipment to PKBSI zoos; supported by the Save the Tiger Fund, a special project of the National Fish and Wildlife Foundation (NFWF) created in partnership with Exxon Corporation; funds for tiger transfers supported by the Zoological Society of London.

(1997) PKBSI Sumatran Tiger Masterplan Workshop to produce this masterplan for management of the PKBSI Sumatran tiger population; supported by the Save the Tiger Fund.

PKBSI Sumatran Tiger Masterplan

2 - 3 April 1997, Taman Safari Indonesia

Lukito Daryadi and Jansen Manansang, PKBSI

In order to effectively manage an endangered species such as the Sumatran tiger in captivity, institutions maintaining these animals must work together to manage them as one large interbreeding population. This requires a comprehensive action plan based upon the analysis of the population and developed by the institutions that will implement it.

This masterplan is that action plan for the Sumatran tiger in Perhimpunan Kebun Binatang Se Indonesia (PKBSI) zoos. It is based upon a studbook database developed and maintained by Ligaya Tumbelaka, PKBSI Sumatran Tiger Studbook Keeper at Taman Safari Indonesia/Bogor Agriculture University. Components of this masterplan include: genetic and demographic population analyses performed by Peter Christie, Western Plains Zoo, Australia in 1995 and subsequently by Kathy Traylor-Holzer, Minnesota Zoo, USA in 1997; and population goals, management strategies and breeding recommendations discussed and developed by the PKBSI Sumatran Tiger Management Committee in April 1997.

Recommendations for population management set forth in this masterplan will be coordinated by the two program co-coordinators, Jansen Manansang from Taman Safari Indonesia, Bogor, and Atje Salfifi from Ragunan Zoo, Jakarta. Implementation is the responsibility of the Sumatran Tiger Management Committee composed of representatives from each of the ten PKBSI zoos maintaining Sumatran tigers: Kebun Binatang Ragunan, Taman Safari Indonesia, Kebun Binatang Bandung, Gembira Loka-Yogyakarta, Timjomoyo Semarang, Satwa Taru Surkarta, Kebun Binatang Surabaya, Griya Satwa Mulya-Medan, Kebun Binatang Jambi, and Kebun Binatang Bukittinggi. Additional recommendations on related issues such as veterinary medicine, husbandry and genome resource banking were made by members of the visiting Sumatran Tiger Project Team in 1995 and follow the masterplan (see Chapter 3).

In 1994 the Ministry of Forestry, Directorate General of Forest Protection and Nature Conservation (PHPA) developed the *Indonesian Sumatran Tiger Conservation Strategy* outlining a conservation program for Sumatran tigers in Indonesia. The objectives of this strategy are to ensure the long-term viability of wild Sumatran tigers in major protected areas of Sumatra, to develop a captive management program for Sumatran tigers in PKBSI zoos, and to link these *in situ* and *ex situ* conservation activities for the reinforcement and recovery of wild populations as part of the IUCN/SSC CBSG *Tiger Global Conservation Strategy.* The *PKBSI Indonesian Sumatran Tiger Masterplan* supports these objectives and is an integral component of this multi-faceted program to conserve the Sumatran Tiger.

Program Goals

The IUCN/CBSG *Tiger Global Conservation Strategy* recommends the maintenance of a world captive population of at least 250 Sumatran tigers managed in four regional programs (see Chapter 1). These tigers should be managed in such a way as to retain a minimum of 90% of the

original genetic diversity acquired from the wild for at least 100 years. The PKBSI Sumatran tiger program is a critical component of this global program. As the range country program, it holds the primary responsibility for preservation of this subspecies in captivity and is the link through which new genetic founders will enter the global captive population.

The goal of the PKBSI Sumatran tiger program is to retain at least 90% of the genetic diversity obtained from the wild for 100 years. The population is currently at carrying capacity with 61 tigers. Based upon calculations using the CAPACITY computer software program, this goal of 90% retention could not be attained with such a relatively small population size without additional founders contributing to the program. The incorporation of more wild-caught founders into the breeding program (either by breeding those already in captivity or through "problem" tigers captured from the wild) will be necessary for the success of the program.

Since the population is currently at carrying capacity, population growth must remain stable, with births and captures balancing deaths and exports unless additional cage spaces are added. The rate of acquisition of problem tigers and the level of exportation of non-breeding tigers to other regional programs will determine the birth rate and annual number of breeding recommendations that can be made within the PKBSI.

Status of Managed Population

Current Inventory

One of the first priorities for the establishment of a managed program is to develop an accurate studbook database for all animals living in captivity within the region. These data can then be used in genetic and demographic analyses to determine the potential importance of each individual animal to the breeding program. Often animals previously thought to be valuable become less valuable after analysis. Reasons for this may include incomplete pedigree, unverified origin, identity confusion, health and reproductive problems, and abundance of relatives in the population.

The PKBSI Sumatran Tiger Regional Studbook is maintained by Ligaya Tumbelaka and is based on information and records supplied by the PKBSI zoos. This studbook database was updated prior to the masterplan meeting and used in the following analyses of the PKBSI Sumatran tiger captive population (see Appendix for studbook report for the living population).

As of 1 April 1997 there are 61 Sumatran tigers (32 males, 29 females) maintained within 10 PKBSI zoos (see Table 1). Of these, 18 (10 males, 8 females) are believed to be wild-caught and the remaining 43 (22 males, 21 females) tigers are captive-born.

The PKBSI Sumatran tiger management committee did not officially designate any of the tigers currently in the population as surplus to the breeding program; therefore, the subsequent analyses include all of the 61 tigers in PKBSI zoos. Criteria to review when considering designating an animal as "surplus" to the genetic and demographic needs of the program include age, health and reproductive status, known pedigree and origin, and representation of founder lines in the population. There may be some individual tigers that will never breed in the future

Table 1. Current status of PKBSI Sumatran tiger population [# males.# females(total#)].

PKBSI Zoo	*# Wild-caught tigers*	*# Captive-born tigers*	*Total # of tigers*
Bandung	0.0 (0)	1.1 (2)	1.1 (2)
Bukittinggi	0.0 (0)	1.1 (2)	1.1 (2)
Jambi	0.0 (0)	1.1 (2)	1.1 (2)
Medan	0.1 (1)	1.0 (1)	1.1 (2)
Ragunan	1.0 (1)	7.3 (10)	8.3 (11)
Semarang	0.1 (1)	1.0 (1)	1.1 (2)
Solo	0.0 (0)	1.1 (2)	1.1 (2)
Surabaya	1.1 (2)	4.6 (10)	5.7 (12)
Taman Safari	8.5 (13)	3.4 (7)	11.9 (20)
Yogyakarta	0.0 (0)	2.4 (6)	2.4 (6)
Total	10.8 (18)	22.21 (43)	32.29 (61)

due to one or more of these factors. It is desirable to remove these animals from the computer analysis in order to get an accurate view of the status of the tiger population.

Verification of Wild-Caught Tigers

It is sometimes best to take a conservative approach when including animals as founders in a managed captive program. This is particularly relevant in situations such as the PKBSI Sumatran tiger program when new founders are likely to become available (e.g., captured problem tigers). Individual animals of undocumented or questionable origin should be excluded from the breeding program until their origin can be verified.

Ten male and eight female Sumatran tigers in the PKBSI population are reputed to be wild-caught in origin (see Table 2). Written documentation of the origin of six individuals (four males, two females) was available at the 1995 PKBSI Masterplan workshop. Documentation for a newly captured female currently held at Medan Zoo was available at this 1997 Masterplan workshop. Documentation is reported to be available for an additional male and female (both at Surabaya) which needs to be submitted immediately to the PKBSI Sumatran Tiger Studbook Keeper and CBSG Tiger Global Coordinator.

Of the remaining nine tigers of unverified origin, five (4.1) have been verified as Sumatran tigers through recent molecular DNA analysis conducted by Stephen O'Brien in the U.S. These tigers are therefore known to be of the Sumatran subspecies, but their origin has not been verified as wild-caught. One additional female (SB# 873) has never reproduced and is too old to breed, so her origin is irrelevant. Verification of the remaining reputed three wild-caught tigers (SB# T9621, T9622 and T9625 at TSI) needs to be pursued immediately; if written documentation or other sources of information are not available, DNA samples from these tigers should be analyzed for subspecies verification.

Table 2. Verification and reproductive history of wild-caught Sumatran tigers in PKBSI zoos.

SB#	*Name*	*Sex*	*Age*	*Location*	*Verification*	*Reproductive history*
866	Hendra	M	9+	TSI	Verified as wild-caught	2.3 offspring; all dead
867	Galuh	M	10	TSI	Sib to SB 868, DNA verified	1.3 living offspring
868	Ago	M	10	TSI	DNA verified as Sumatran	No offspring
870	Bagira	M	9+	TSI	Verified as wild-caught	No offspring
871	Bokir	M	9+	TSI	DNA verified as Sumatran	No offspring
872	Bukit	M	6+	TSI	Verified as wild-caught	No offspring
874	Medan	M	10+	TSI	Verified as wild-caught	Breedings produced no pregnancy/ possibly sterile
885	Kulu	M	6+	Ragunan	DNA verified as Sumatran	No offspring
T9615	Ujang	M	3+	Surabaya	Documentation pending	No offspring
T9625	Simba	M	3+	TSI	Unverified	No offspring
869	Tera	F	8+	TSI	Verified as wild-caught	2.3 offspring; all dead
873	Elis	F	26+	TSI	Unverified	No offspring/ too old
884	Manis	F	14+	Semarang	DNA verified as Sumatran	0.1 offspring; dead
908	Deli	F	11+	Surabaya	Documentation pending	12 (5.7) living descendants
T9590	Cane	F	5	TSI	Verified as wild-caught	No offspring
T9621	Lady	F	?	TSI	Unverified	No offspring
T9622	Tari	F	?	TSI	Unverified	No offspring
T9629	Tele	F	?	Medan	Verified as wild-caught	No offspring

Genetic Analyses

Information on the Sumatran tiger population contained in the studbook was analyzed using the GENES computer software program developed by Robert Lacy. This program models the passing of genetic material (alleles) through the population and allows the assessment of the genetic status of the population based upon the breedings that have already occurred in captivity. The resulting genetic summary is based upon the descendant (captive-born) population. Wild-caught tigers are not considered to have contributed to the population until they reproduce and leave surviving offspring that carry their genetic background. It is therefore important that wild-caught animals reproduce so that they can serve as new founders to the captive population.

Wild-caught individuals are assumed to be unrelated to each other unless there is evidence otherwise. Two of the wild-caught males currently at Taman Safari (SB# 867 and 868) were obtained together as cubs of the same age and were assumed to be siblings for these analyses. In this case, their wild parents are considered founders (WILD1 and WILD2) rather than the cubs themselves.

Founder Representation

The management strategy that preserves the most genetic diversity in the captive population is to keep the representation of each of the founder lines as equal as possible. Ideally, each founder should produce the same number of offspring over its lifetime. Realistically, this is seldom possible and has not been done in the past. The task of the management committee of a newly

established managed captive program is to assess the current founder representation in the population and to equalize it as much as possible. This means breeding new founders or those with few offspring or relatives in the population while suspending reproduction in individuals related to overrepresented founders.

The descendant PKBSI Sumatran tiger population is currently based upon 16 founders. Of these 16 founders, only one remains in the PKBSI tiger program (female SB# 908), with two sibling wild-caught males representing another two wild founders not in captivity. The remaining 13 founders are dead and are represented through their captive-born descendants.

Among these 16 existing founder genetic lines, representation is unequal. Most notably, founders 371♂ and 370♀ bred at Ragunan Zoo represent over 54% of the genetic background of the entire PKBSI Sumatran tiger descendant population (see Fig. 1). For comparison, if representation were equal among the 16 founders, two founders would represent only 12.5%.

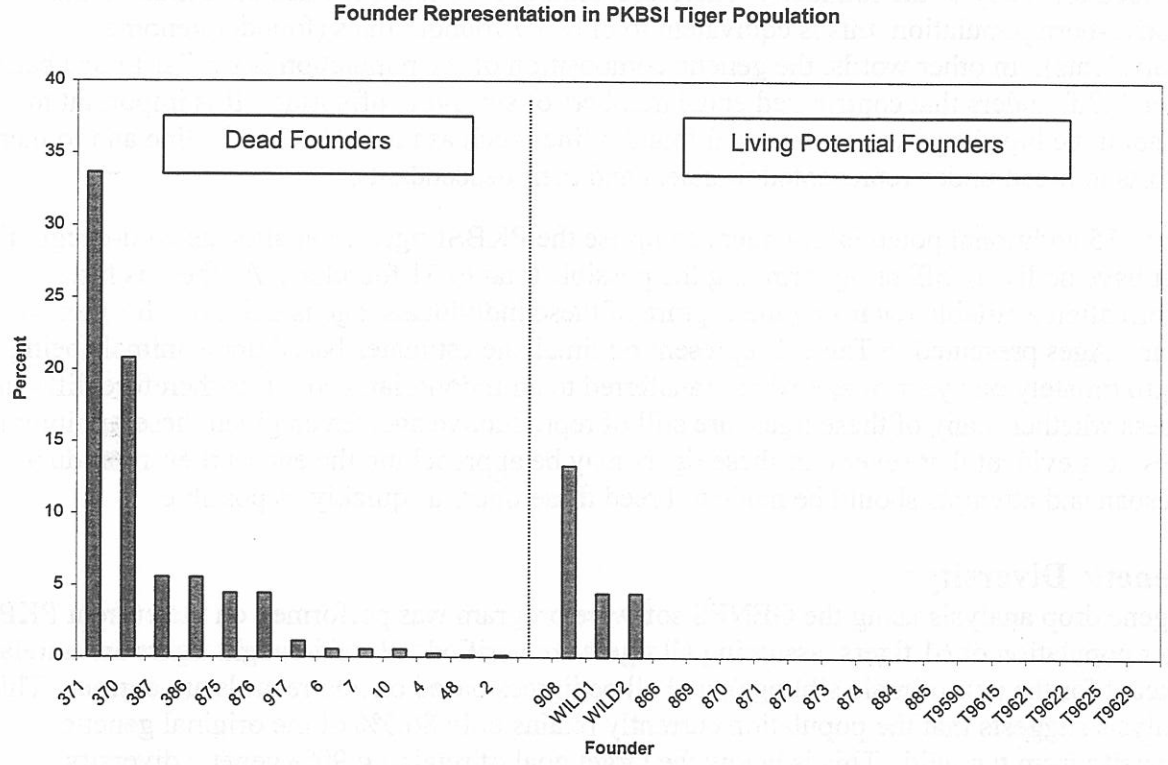

Fig 1. Founder representation in the descendant PKBSI Sumatran tiger population.

Only two of the living wild-caught tigers in the PKBSI tiger program have living offspring. Male SB# 867 has four offspring (all currently at TSI); these four tigers are also the only living descendants of the TSI founder lines SB# 875 and 876 which are still of reproductive age (Fig. 2). Therefore, these four offspring represent four founders (SB# 875, 876, WILD1 and WILD2). Female SB# 908 has 12 living descendants, all crossed with the overrepresented Ragunan founder line (SB# 370 and 371) (Fig. 2).

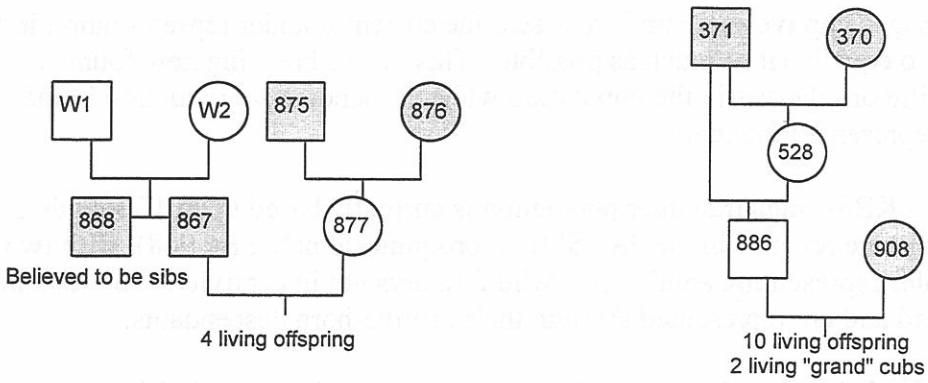

Fig. 2. Pedigree of two living possibly wild-caught tigers which have living offspring (shaded boxes are wild-caught tigers; W1=WILD1; W2=WILD2).

Unequal representation means that only a very small portion of the genetic material has been retained for many of the founders. Therefore, although 16 founder lines contribute to the captive-born population, this is equivalent to only 3.7 founder lines (founder genome equivalents). In other words, the genetic composition of the population is similar to one based upon 3.7 founders that contributed equal numbers of surviving offspring. It is important to discontinue breeding over-represented founder lines such as the SB# 370/371 line and to increase efforts to breed under-represented founders and their descendants.

Up to 15 additional potential founders comprise the PKBSI tiger population as wild-caught tigers that have no living offspring, bringing the possible total to 31 founders. As there is little information available regarding the capture of these individuals, age is unknown for most of them. Ages presented in Table 2 represent minimal age estimates based upon animals being approximately one year of age when transferred to an Indonesian zoo. It is therefore difficult to assess whether many of these tigers are still of reproductive age. Even given these minimum ages, it is evident that several of these tigers may be approaching the end of their reproductive lifespan and attempts should be made to breed these tigers as quickly as possible.

Genetic Diversity

A gene drop analysis using the GENES software program was performed on the current PKBSI tiger population of 61 tigers, assuming all tigers are verified, all wild-caught tigers are unrelated (except for the pair of male siblings), and all pedigrees based on zoo records are correct. This analysis suggests that the population currently retains only 86.5% of the original genetic diversity from the wild. This is below the target goal of retaining 90% genetic diversity.

Gene diversity generally decreases in a captive population unless new genetic lines are introduced and bred sufficiently. If the wild-caught founders currently in the tiger program were bred optimally, the potential amount of genetic diversity that could be retained is 97.9%. Under such management, the number of founder genome equivalents would increase from 3.7 to 23.3. Since we cannot control variable factors such as fertility and litter size, "perfect" management is not achievable; however, this analysis demonstrates the potential benefits of a more effective and comprehensive breeding program. As additional "problem" tigers enter the captive population as new founders, it will be possible to continue to maintain a high percent of genetic diversity in the program.

Inbreeding

Inbreeding, or the breeding of related animals, results in a loss of genetic diversity in the population and can also be associated with physiological and morphological problems such as reduced fertility and high neonatal mortality. Inbreeding cannot always be avoided in a small captive population, but it is desirable to minimize inbreeding when possible. Inbreeding is measured by the inbreeding coefficient F, with F = 0 indicating that the animal's parents are unrelated. In comparison, offspring of a father-daughter or brother-sister mating would have an F = 0.2500.

Overall there is a relatively low level of inbreeding in the PKBSI tiger population, with the average F = 0.0820. For 46 of the 61 tigers, there is no inbreeding (F = 0). One tiger imported from Europe (SB# 543) is slightly inbred (F = 0.1250). Twelve tigers have an F = 0.2500, all of which are from the SB# 370/371 genetic line. Two tigers have an F = 0.2812 (SB# T9600 and T9601) and are a cross between the 370/371 line and the SB# 908 line. Since these tigers are from over-represented lines, they should not be bred within the PKBSI population and should definitely not be bred to each other, which would result in further inbreeding.

Mean Kinship

Determining good genetic pairs of tigers for breeding that would equalize founder representation is not always simple. The GENES analysis aids in these decisions by calculating a measurement for each animal called mean kinship, which measures how related each animal is to the rest of the descendant population. The GENES program produces a list of living animals ranked according to mean kinship, with males in the left column and females in the right. The animals with the lowest mean kinship value are at the top of the list. These animals are the least related to others in the population and are therefore the most valuable animals to breed. The mean kinship list is a very valuable tool in determining the most genetically valuable animals in the population.

The mean kinship list in Figure 3 emphasizes the value of potential founders to the PKBSI program that have not yet bred. These individuals, representing the top eight males and top seven females, have a mean kinship value of 0, indicating that they have no relatives in the population. Descendants of overrepresented lines are found nearer the bottom of the list.

The mean kinship of an animal changes each time it (or any of its relatives) produce offspring, or when any of its relatives die or leave the population. It is therefore important that the studbook be kept current and that an analysis is performed on the current population prior to making breeding recommendations. Declaring an animal "surplus" also removes it from the analysis and affects the rankings of the remaining animals. For instance, the SB# 908 founder line is well-represented with 12 descendants (see Fig. 2), decreasing the breeding value of wild-caught female 908. However, all of 908's descendants also contain the 370/371 founder lines. If these tigers were declared surplus to the program, then 908's mean kinship value would become 0 and she would be considered a highly valuable female to breed.

Rank	MALES	Name	MK	Age	Location	FEMALES	Name	MK	Age	Location
1	874	Medan	.0000	12	BOGOR	T9629	Tele	.0000	?	MEDAN
2	866	Hendra	.0000	10	BOGOR	873	Elis	.0000	27	BOGOR
3	870	Bagira	.0000	10	BOGOR	884	Manis	.0000	15	SEMARANG
4	871	Bokir	.0000	10	BOGOR	T9621	Lady	.0000	10	BOGOR
5	885	Kulu	.0000	8	JAKARTA	869	Tera	.0000	9	BOGOR
6	872	Bukit	.0000	7	BOGOR	T9590	Cane	.0000	6	BOGOR
7	T9615	Ujang	.0000	3	SURABAYA	T9622	Tari	.0000	2	BOGOR
8	T9625	Simba	.0000	2	BOGOR	934	Tipuk	.0361	8	YOGYAKARTA
9	543	Coklat	.0125	12	BOGOR	877	Neneng	.0388	19	BOGOR
10	878	Ujang	.0277	19	BOGOR	879	Rai	.0444	7	BOGOR
11	868	Ago	.0277	12	BOGOR	880	Rake	.0444	7	BOGOR
12	867	Galuh	.0388	12	BOGOR	882	Butet	.0444	5	BOGOR
13	881	Ucok	.0444	5	BOGOR	908	Deli	.0666	11	SURABAYA
14	532	Bagus	.0555	14	YOGYAKARTA	940	Srikan	.1375	7	YOGYAKARTA
15	935	Bagus	.1375	8	MEDAN	941	Arimbi	.1375	7	YOGYAKARTA
16	942	Budi	.1375	5	BANDUNG	943	Lisa	.1375	5	SOLO
17	954	Kliwon	.1375	4	YOGYAKARTA	953	Wage	.1375	4	BANDUNG
18	T9603	Novi	.1416	14	SEMARANG	913	Altea	.1500	7	SURABAYA
19	912	Melcolm	.1500	7	SOLO	T9596	Melly	.1500	4	SURABAYA
20	915	British	.1500	5	SURABAYA	T9627	Septi	.1500	1	SURABAYA
21	916	Nelly	.1500	5	SURABAYA	T9628	Hesti	.1500	1	SURABAYA
22	T9595	Bonnie	.1500	4	SURABAYA	910	Marry	.1548	8	SURABAYA
23	909	Coldren	.1548	8	SURABAYA					
24	535	Nopa	.1694	14	JAKARTA	T9600	Jusmi	.1604	4	SURABAYA
						T9601	Jusni	.1604	4	SURABAYA
25	895	Rama	.1909	8	JAKARTA	898	Rambi	.1909	7	JAKARTA
26	896	Tony	.1909	8	JAKARTA	906	Sella	.1909	6	JAMBI
27	897	Rambo	.1909	7	JAKARTA	T9614	Chika	.1909	3	JAKARTA
28	904	Rangga	.1909	6	JAMBI	528	Raguni	.2013	16	JAKARTA
29	905	Erick	.1909	6	JAKARTA	887	Ricana	.2097	12	YOGYAKARTA
30	945	Vigo	.1909	3	JAKARTA					
31	T9613	SEMI	.1909	3	JAKARTA					
32	886	Kubu	.2236	12	SURABAYA					

Fig. 3. Ordered mean kinship list for the PKBSI Sumatran tiger population by sex.

Tigers in the approximate top third of the list (above the break) are either wild-caught or under-represented captive-born individual. They are the most genetically valuable animals, and these animals should be paired with each other for breeding as much as possible before breeding recommendations are considered for animals lower on the mean kinship list.

Tigers in the middle portion of the list are captive-born descendants of the over-represented 370/371 founder line in combination with other under-represented lines. These individuals are of moderate genetic value to the PKBSI tiger population. Some of these tigers may be bred in the future, but most will not. Several of these tigers would make good candidates for consideration for exportation to other regional tiger programs without negatively impacting the PKBSI Sumatran tiger program. For instance, many of these animals descend from founders 370, 371 and 908, none of which are represented in the European EEP Sumatran tiger population.

Tigers in the bottom portion of the list are almost completely descended only from the 370/371 founder line and are also inbred. These tigers should not be bred, particularly with each other. Some of these animals, particularly the older individuals, could be designated as surplus to the managed breeding program and could be transferred to non-PKBSI facilities, if desirable, to provide more space for more genetically valuable Sumatran tigers in PKBSI zoos.

Demographic Analyses

Population Census

A census of the Sumatran tiger population in the ten PKBSI zoos based on the studbook data show a steady increase in the population starting in 1966 up until 1994, when the population leveled off at about 60 tigers (Fig. 4). The average annual growth rate over the last 30 years has been about 15% (lambda = 1.15). Growth in the last five years since the establishment of the PKBSI Sumatran tiger program has averaged 7% annually. No growth was observed between 1994-1996 due to the suspension of breeding attempts pending DNA analysis and related verification issues.

Fecundity and Mortality

Based on past PKBSI zoo records the primary reproductive span for female Sumatran tigers is during 3-12 years of age, with a peak around eight years. Males are primarily reproductive between 4-10 years of age, peaking around 7-8 years. This information is based upon how the tigers were managed and bred in the past and only suggest the reproductive lifespan and capabilities of the subspecies. The average generation time is about seven years.

Litter sizes range from 1-5, with an average of 2.6 cubs per litter. Neonatal mortality within the first 30 days of birth is 25% (22 out of 88 births). Of those tigers that survive the first few months after birth, most live to at least 10-13 years of age. Mortality rates increase steadily after 14 years of age, with few tigers living to be 20 years old.

Population Age Structure

The majority (n=45) of the tigers currently in the PKBSI program are estimated to be of breeding age (i.e., 3-11 years old). There are only five tigers under three years old due to the breeding suspension of the last two years. Since there are a sufficient number of breeding age animals, it will not be difficult to produce enough cubs in the next several years to keep the population from declining as the breeders age.

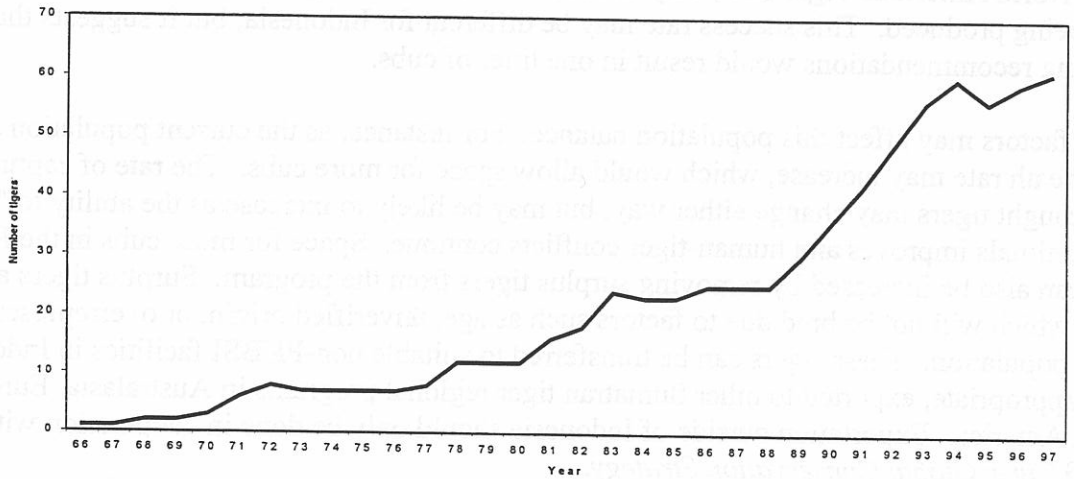

Fig. 4. Census of Sumatran tigers in Indonesian zoos from 1966 – 1997.

Population Dynamics

The size of the population is determined by the rate at which tigers enter and leave the population. Tigers can enter the PKBSI program in three ways: through births in the captive population, through transfer of wild-caught problem tigers or acquisition of similar wild-caught tigers within Indonesia, or through importation of tigers from other countries. There is no need for the PKBSI program to import tigers, so only births and acquisition of wild-caught animals will be considered. Tigers can also leave the program in three ways: through death, transfer to a non-PKBSI facility in Indonesia, or exportation to another tiger regional program.

The PKBSI Sumatran tiger program currently has a capacity of about 60 tigers. This means that the population needs to be managed for no growth, with the number of tigers entering the program balancing the number of tigers leaving the program. If additional cage spaces are created by construction of new facilities and/or conversion of other exhibits (e.g., Siberian or Bengal tiger exhibits) into additional spaces for Sumatran tigers, then population growth can be allowed until the program once again reaches carrying capacity.

Over the last six years, the average number of adult deaths in the PKBSI tiger population has been about two tigers per year. One additional tiger per year has been transferred to a non-PKBSI facility within Indonesia. No exportations have taken place. Therefore the average rate of loss of adult tigers from the population has been about three tigers per year.

About one wild-caught tiger has entered the program each year during this same period. If this rate continues, then only about two surviving cubs can enter the program each year in order to keep the population size stable. Given an average litter size of 2.6 cubs and 25% neonatal mortality, this suggests only one litter should be produced on average each year to prevent further population growth.

Not every breeding recommendation made by the PKBSI Sumatran tiger management committee is likely to produce a litter. Success rate is dependent upon factors such as compliance rate on relocating tigers from one zoo to another and age, health, fertility and compatibility of the tigers. In the North American Tiger SSP, only about 50-70% of breeding recommendations results in a litter being produced. This success rate may be different for Indonesia, but it suggests that two breeding recommendations would result in one litter of cubs.

Many factors may affect this population balance. For instance, as the current population ages, adult death rate may increase, which would allow space for more cubs. The rate of capture of wild-caught tigers may change either way, but may be likely to increase as the ability to "rescue" these animals improves and human-tiger conflicts continue. Space for more cubs in the PKBSI zoos can also be increased by removing surplus tigers from the program. Surplus tigers are those tigers which will not be bred due to factors such as age, unverified origin, or overrepresentation in the population. These tigers can be transferred to suitable non-PKBSI facilities in Indonesia or, if appropriate, exported to other Sumatran tiger regional programs in Australasia, Europe or North America. Exportation outside of Indonesia should only be done in cooperation with the CBSG *Tiger Global Conservation Strategy*.

Management Recommendations

Breeding Recommendations

Given the large number of wild-caught founders that have not yet reproduced, priority should be given to pairing tigers verified as wild-caught. The breeding of wild-caught tigers should take priority over breeding of captive-born animals to retain as much genetic diversity as possible. Captive-born tigers that derive from overrepresented genetic lines, primarily descendants of founders SB# 370 and 371, should not be bred, and in particular, they should not be bred to each other to avoid further inbreeding.

Breeding pairs formed using the mean kinship ranked list will follow a similar strategy. Pairs ideally should be formed from the top of the mean kinship list, working down the list as needed. Individuals near the top of the list should be paired with each other and should not be paired with tigers near the bottom. This would link rare genetic lines with common ones (e.g., the 908 line is currently linked with the 370/371 line). This makes it impossible in the future to increase the rare genes without also increasing the common ones, and prevent equal founder representation. Once a potential pair has been selected, the GENES program can simulate a breeding between the selected tigers and display the resulting impact on the genetic measures of the population. The management committee can then easily evaluate whether such a breeding would be to the benefit or detriment of the program. Potential breeding pairs should also be checked for the inbreeding coefficient of the resulting offspring, and pairings resulting in $F > 0.10$ should be avoided.

Given all of the above considerations, the PKBSI Sumatran Tiger Management Committee made the following breeding recommendations at the masterplan meeting (Table 3). This committee will review the status of these breeding recommendations at its next meeting in November 1997.

Table 3. Current breeding recommendations for PKBSI Sumatran tiger population.

Male				Female					
SB#/ Name	MK Rank	Origin	Current Location	SB#/ Name	MK Rank	Origin	Current Location	Breeding Location	Inbreed. Coeff.
872 Bukit	High	Wild	Taman Safari	869 Tera	High	Wild	Taman Safari	Taman Safari	0.0000
866 Hendra	High	Wild	Taman Safari	T9590 Cane	High	Wild	Taman Safari	Taman Safari	0.0000
870 Bagira	High	Wild	Taman Safari	882 Butet	Mod.	Capt. (none)	Taman Safari	Taman Safari	0.0000
935 Bagus	Mod.	Capt. (none)	Medan	T9629 Tele	High	Wild	Medan	Medan	0.0000
T9615 Ujang	High	Wild	Surabaya	908 Deli	Mod.	Wild	Surabaya	Surabaya	0.0000
881 Ucok	Mod.	Capt. (none)	Taman Safari	941 Arimbi	Mod.	Capt. (50%)	Yogyakarta	Yogya.	0.0000
885 Kulu	High	Wild	Ragunan	940 Srikandi	Mod.	Capt. (50%)	Yogyakarta	Ragunan	0.0000

-- Number in ( ) for captive-born tigers represents the amount of overrepresented 370/371 line in that individual.
-- The last two breeding recommendations (in italics) are pending the transfer of tigers between institutions.

Animal-by-Animal Recommendations

The analyses and considerations presented above can be used to generate specific recommendations for each animal in the PKBSI Sumatran tiger population. Such recommendations may include the need for origin or subspecies verification, breeding status and potential mates, designation as surplus to the breeding program, or availability for possible exportation to other regional captive programs. These recommendations are listed here, grouped by institution.

Ragunan

528♀ "Raguni"	Designate as surplus due to age and overrepresentation.
535♂ "Nopa"	Hold for re-evaluation in future, or designate as surplus (unlikely to be bred again due to age and overrepresentation).
885♂ "Kulu"	Possibly wild-caught; should be bred; should pair with a genetically valuable female from another PKBSI zoo (possible recommendation to breed with 940♀ Srikandi from Yogyakarta). No documentation of wild-caught status on file.
895♂ "Rama" 896♂ "Tony" 897♂ "Rambo" 898♀ "Rambi" 905♂ "Erick" 945♂ "Vigo" T9613♂ "Semi" T9614♀ "Chika"	These eight full siblings are of low genetic value from an overrepresented line, are inbred (F = 0.2500), and most of them should not be bred. Some of the older individuals may be designated as surplus. **Do not breed any of these siblings to each other, as the offspring will be very inbred (F = 0.3750).**

Yogyakarta

532♂ "Bagus"	Moderate genetic value; hold for future re-evaluation (but may be too old to breed again).
887♀ "Ricana"	Designate as surplus due to age, inbreeding and overrepresentation.
934♀ "Tipuk"	Most valuable captive-born female in population; should breed with wild-caught male or very valuable captive-born male (such as 881♂ Ucok at TSI).
940♀ "Srikandi"	Moderate genetic value; potential breeder after more valuable females have been paired with mates; possible recommendation to transfer to Ragunan to breed with 885♂ Kulu.
941♀ "Arimbi"	Moderate genetic value; potential breeder after more valuable females have been paired with mates; possible recommendation to breed with 881♂ Ucok from TSI.
954♂ "Kliwon"	Moderate genetic value; do not breed now, but keep in managed population for future evaluation. This male has five full siblings in the PKBSI program and is less likely to get a breeding recommendation than his female siblings. He is a potential candidate for exportation to another regional tiger program.

Full siblings 940♀, 941♀ and 954♂ should not be bred to each other, which would result in inbred offspring (F = 0.2812).

Taman Safari

543♂ "Coklat"	Most valuable captive-born male in population; possibly transfer soon to another PKBSI facility for breeding with valuable captive-born female before too old to breed.
866♂ "Hendra"	Top priority breeder (verified wild-caught with no living offspring); current recommendation to breed with T9590♀ Cane.
867♂ "Galuh"	High genetic value (potential wild-caught); breed as soon as mate becomes available. No documentation of wild-caught status on file.
868♂ "Ago"	High genetic value (potential wild-caught); breed as soon as mate becomes available; higher priority than sibling 867♂ Galuh. No documentation of wild-caught status on file.
869♀ "Tera"	Top priority breeder (verified wild-caught with no living offspring); current recommendation to breed with 872♂ Bukit.
870♂ "Bagira"	Top priority breeder (verified wild-caught with no living offspring); current recommendation to breed with 882♀ Butet.
871♂ "Bokir"	High genetic value (potential wild-caught); breed as soon as mate becomes available. No documentation of wild-caught status on file.
872♂ "Bukit"	Top priority breeder (verified wild-caught with no living offspring); current recommendation to breed with 869♀ Tera.
873♀ "Elis"	Designate as surplus due to age.
874♂ "Medan"	Top priority breeder (verified wild-caught with no living offspring); may possibly be sterile; consider pairing with new female if available.
877♀ "Neneng"	Designate as surplus due to age.
878♂ "Ujang"	Designate as surplus due to age.
879♀ "Rai"	High genetic value; should be paired with wild-caught male.
880♀ "Rake"	High genetic value; should be paired with wild-caught male.
881♂ "Ucok"	Moderate to high genetic value; should be considered for transfer to another PKBSI zoo for pairing with valuable female; possible recommendation for breeding with 941♀ Arimbi at Yogyakarta (but 934♀ Tipuk would make better pair).
882♀ "Butet"	High genetic value; current recommendation to breed with 870♂ Bagira.
T9590♀ "Cane"	Top priority breeder (verified wild-caught with no living offspring); current recommendation to breed with 866♂ Hendra.
T9621♀ "Lady" T9622♀ "Tari" T9625♂ "Simba"	Verify wild-caught status; otherwise, analyze DNA for subspecies verification. Upon verification, pair for breeding with wild-caught mate.

Semarang

884 ♀ "Manis"	High genetic value and should be bred, but is probably too old to breed. Pair with T9603 ♂ Novi, or otherwise designate as surplus.
T9603 ♂ "Novi"	Moderate genetic value, but is possibly too old to breed. Pair with 884 ♀ Manis, or otherwise designate as surplus.

These two tigers could be paired for breeding if desired, as any offspring would be genetically valuable, but the chance of successful reproduction is small due to their age.

Solo

912 ♂ "Melcolm"	Moderate genetic value; do not breed now, but hold for re-evaluation pending verification of dam 908's wild-caught status.
943 ♀ "Lisa"	Moderate genetic value; do not breed now, but keep in managed population for future evaluation.

Surabaya

886 ♂ "Kubu"	Designate as surplus due to inbreeding and overrepresentation.
908 ♀ "Deli"	Submit documentation of wild-caught origin; breed to wild-caught male (current recommendation to breed with T9615 ♂ Ujang).
T9615 ♂ "Ujang"	Submit documentation of wild-caught origin; breed to wild-caught female (current recommendation to breed with 908 ♀ Deli).
909 ♂ "Coldren" 910 ♀ "Marry" 913 ♀ "Altea" 915 ♂ "British" 916 ♂ "Nelly" T9595 ♂ "Bonnie" T9596 ♀ "Melly": T9627 ♀ "Septi" T9628 ♀ "Hesti"	These nine full siblings need to be verified through the verification of dam 908's wild-caught status; they should not be bred, but with verification of origin, they can be kept as part of the managed population for future evaluation. Some of the younger individuals are possible candidates for exportation to other regional tiger programs, as few if any of these siblings are likely to be recommended for breeding. **Do not breed any of these siblings to each other, as the resulting offspring would be inbred (F = 0.2812).**
T9600 ♀ "Jusmi"	Designate as surplus due to inbreeding and overrepresentation.
T9601 ♀ "Jusni"	Designate as surplus due to inbreeding and overrepresentation.

Except for the two possibly wild-caught tigers, none of these animals should be bred with each other, as they are all related to each other and represent overrepresented genetic lines.

Bandung

942♂ "Budi"	Moderate genetic value; do not breed now, but keep in managed population for future evaluation.
953♀ "Wage"	Moderate genetic value; do not breed now, but keep in managed population for future evaluation.

Do not breed this pair together; this would result in overrepresented and inbred offspring (F = 0.2812).

Jambi

904♂ "Rangga"	Low genetic value and inbred; do not breed.
906♀ "Sella"	Low genetic value and inbred; do not breed.

Do not breed these inbred siblings to each other, as this would produce very inbred offspring (F = 0.3750).

Medan

935♂ "Bagus"	Moderate genetic value; current recommendation to breed with T9629♀ Tele.
T9629♀ "Tele"	Top priority breeding female (verified wild-caught with no living offspring); current recommendation to breed with 935♂ Bagus.

Summary of Analyses Recommendations

The following is a list of recommendations based upon the population analyses outlined above and designed to guide the management of the PKBSI Sumatran Tiger program.

1. Documentation verifying the wild-caught status of one male (SB# T9615, Ujang) and one female (SB# 908, Deli) tiger at Surabaya needs to be submitted immediately to the PKBSI Sumatran Tiger Studbook Keeper and CBSG Tiger Global Coordinator. This is essential in order to determine the genetic value of not only this female but also her twelve offspring.

2. Verification of the three potentially wild-caught tigers (SB# T9621, Lady; T9622, Tari; and T9625, Simba) at Taman Safari needs to be pursued immediately. Written documentation should be submitted to the PKBSI Sumatran Tiger Studbook Keeper and CBSG Tiger Global Coordinator. If written documentation or other sources of information are not available, DNA samples from these tigers should be analyzed for subspecies verification.

3. Efforts should be continued to locate any documentation of wild-born origin for those tigers that are reputedly wild-caught and have been verified as Sumatran by DNA analysis.

4. Further molecular DNA analyses may be desirable to confirm that founders to the population are unrelated. Similar molecular analyses could be used to verify paternity or parentage of any tigers for which zoo records may be in question.

5. Breeding of verified wild-caught Sumatran tigers should take priority over the breeding of unverified or captive-born individuals. This can substantially increase the number of founders to the PKBSI Sumatran tiger population. Four males and three females are currently verified as wild-caught, none of which have living offspring. These tigers should be paired for breeding and should continue to be bred to each other as long as they produce healthy offspring. Unsuccessful pairs should be re-evaluated for possible repairing with new breeding partners.

6. Captive-born tigers that are descendants of the 370/371 founder line should not be bred within the PKBSI unless no other mates are available for wild-caught or genetically valuable breeders. To avoid inbreeding, descendants of 370/371 should not be bred to each other.

7. Tigers that are no longer reproductive due to advanced age or health problems should be declared as surplus to the PKBSI managed population. Removal of these individuals from the genetic analyses can potentially change the genetic value of those tigers remaining in the program. Surplus tigers can remain at their current institution, be transferred to another PKBSI institution for non-breeding, exhibition purposes, or transferred to a non-PKBSI institution.

8. There are two sets of sibling tigers (one set of ten and one set of seven) that are of moderate genetic value to the PKBSI program. Only a few of these tigers will likely ever receive breeding recommendations; the rest will eventually become surplus as they age. One or more of these tigers might be considered as potential candidates for exportation to other regional tiger programs in Australasia, Europe and North America through the CBSG Tiger Global Conservation Strategy.

Edited by Kathy Traylor-Holzer, Population Management Advisor to the AZA Tiger Species Survival Plan and the IUCN/SSC CBSG Tiger Global Conservation Strategy.

Global Conservation Strategy for Captive Sumatran Tigers

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The *Tiger Global Conservation Strategy* (GCS) is a program of the Conservation Breeding Specialist Group (CBSG) of the Species Survival Commission of the World Conservation Union (IUCN). It is designed for the management of about 1,250 studbook-registered tigers distributed among nine regional programs on an international level, and links, when appropriate, *ex situ* and *in situ* conservation activities for the recovery and/or long-term maintenance of captive and wild populations.

The principles of the *Tiger GCS* were first conceived at a CBSG-organized international tiger workshop in Edinburgh, Scotland in July 1992. A global analysis of captive and wild populations of all tiger subspecies indicated a severe, recent decline in wild tiger populations and an urgent need for an integrated global management program for captive tigers. The initial document, the *Tiger Global Animal Survival Plan*, (Tilson *et al.*, 1993) was restructured and renamed in 1996 to *Tiger Global Conservation Strategy* (GCS) to better reflect program goals.

The management committee of the *Tiger GCS* is comprised of representatives from seven tiger range countries, three regional programs (Australia, Europe, Japan and North America) and three additional individuals (International Studbook Keeper, IUCN CBSG Chair and IUCN Cat Specialist Group Chair), who collectively elect a coordinator who is responsible for implementing the program. The Indonesian representative for the *Tiger GCS* is Jansen Manansang, PKBSI Sumatran Tiger Co-coordinator.

Program Goals

The purpose of the *Tiger GCS* is to integrate tiger conservation activities among the world's zoos by providing a communication network and a strategic framework for the most efficient use of resources for the species. Program goals of the *Tiger GCS* include:

- *Interregional program coordination.* A primary focus of the *Tiger GCS* is on captive management programs that can serve as genetic and demographic reservoirs to support the survival and/or the recovery of wild populations in the future. This can be accomplished most effectively by dividing responsibility for maintaining minimum nucleus populations of the five tiger subspecies among the regional programs, and by managing each subspecies on a global level by arranging interactions for tiger or genome exchanges among regional management programs to achieve global and regional goals.
- *Linking ex situ and in situ programs.* A second focus is to integrate conservation management strategies for captive and wild tiger populations. Increased communication and cooperation between the zoo community and relevant forestry departments and protected areas facilitates management of wild "problem" tigers (e.g., tigers outside boundaries of protected areas in conflict with humans) and other issues relative to increased viability of both captive and wild populations.

- *Ex situ support of in situ efforts.* A third focus is to identify where and how the world captive community can provide financial and technical support for *in situ* tiger conservation efforts for wild populations.

Current Status of Captive Populations

The *Tiger GCS* recognizes the perilous state of wild populations of tigers throughout their natural range in Asia. All five extant tiger subspecies are threatened with extinction and are in need of conservation action: *Panthera tigris altaica* (Siberian), *P.t. amoyensis* (South China), *P.t. corbetti* (Indochinese), *P.t. sumatrae* (Sumatran), and *P.t. tigris* (Bengal) (Nowell and Jackson, 1996). In terms of the new Mace-Lande criteria of risk applied by the IUCN, two tiger subspecies (Indochinese and Bengal) are classified as endangered, and three subspecies (South China, Siberian and Sumatran) are critically endangered.

All five tiger subspecies are present in captivity (Tilson *et al.*, 1993). The size and status of the captive population and the stage of development for the regional captive management programs vary among the subspecies, with the Siberian and Sumatran tiger captive populations being the most secure. There are 1,250 studbook-registered tigers in captivity in the 1995 *International Tiger Studbook* (Müller, 1995). A large number of unregistered tigers are also kept in circuses, private facilities and non-participating zoos, but are not part of regional captive programs and therefore are not included below.

Sumatran Tiger: There are about 240 captive Sumatran tigers managed primarily by the Indonesian PKBSI Sumatran Tiger Program, the European EEP and the North American SSP, with a smaller population managed by the Australasian Species Management Program (ASMP). Wild-caught "problem" tigers are expected to provide new founder stock for the PKBSI population which will eventually supply the other regional programs. Genetic diversity is high (80-90%), but additional founders are needed to expand the regional programs outside of Indonesia. Since 1992 the PKBSI zoos have developed a regional studbook (Ligaya, 1997), translated the husbandry manual into Bahasa Indonesia, drafted a masterplan, and established a Genome Resource Bank with cryopreserved samples from most of their tiger specimens.

Siberian Tiger: Captive population is approximately 625 tigers managed primarily the EAZA European Endangered Species Program (EEP) in Europe (which includes Russia) and by the AZA Tiger Species Survival Plan (SSP) in North America. A third large population is managed by the JAZGA in Japan. Genetic diversity in the SSP and EEP is high (96%), founder stock is sufficient, and inbreeding is relatively low (Traylor-Holzer, 1996). A Russian version of the AZA Tiger SSP's tiger husbandry manual (Tilson *et al.*, 1994) has been distributed to Russian zoos. Sperm and other biosamples have been cryopreserved from genetically important tigers in the U.S., Europe and Russia (Wildt *et al.*, 1995; Christie, 1997).

Bengal Tiger: Almost all of the 300 studbook-registered Bengal tigers are managed within Indian zoos, including some tigers carrying the gene for the white coat. The Central Zoo Authority has compiled a regional studbook (Central Zoo Authority, 1995) and is developing a cooperation management program among Indian zoos. Husbandry manuals have been distributed to the Indian zoos managing tigers. The European EEP is likely to develop its captive Bengal tiger population to serve as the secondary managed population for this subspecies.

South China Tiger: All of the 50 captive South China tigers are maintained by 19 Chinese zoos of the CAZG. This population retains 78% of the genetic diversity from its six founders, and exhibits high levels of inbreeding (mean F = 0.25) (Traylor-Holzer and Tilson, 1996). Additional founders may not be available from the wild (Tilson, Traylor-Holzer and Qiu, 1997). The CAZG has established a regional studbook (Li, 1995) and a cooperative management plan for this subspecies (Wang *et al.*, 1995). A Chinese version of the husbandry manual has been distributed to CAZG zoos, and a Genome Resource Bank has been established to maintain cryopreserved samples from about 20 of the remaining captive specimens (Tilson *et al.*, 1996; Tilson, Traylor-Holzer and Qiu, 1997).

Indochinese Tiger: Only 32 Indochinese tigers are registered in the *International Tiger Studbook*, although additional tigers are believed to be maintained in captivity throughout Southeast Asia and need to be verified and registered (Tilson *et al.*, 1995). Most of these tigers are maintained in Malaysia and Singapore, with a small population also managed by the North American SSP. Additional founders are needed, and regional programs need to be integrated and expanded. The husbandry manual has been translated into Thai and Vietnamese and distributed to appropriate zoos.

Management of the Global Captive Sumatran Tiger Population

As a first priority, a captive management program for each subspecies should be developed in its range country or region. The *Tiger GCS* strives to assist range countries in developing effective tiger captive management programs for their endemic subspecies, which typically include a regional studbook, husbandry manual, adequate facilities, staff training, masterplan, genome resource bank, and education program linked to *in situ* tiger programs (Armstrong *et al.*, 1996). For maximum security against unexpected risks, extension of the captive management program to at least one additional region outside the range country is also recommended for each subspecies.

Minimum target population goals for global captive populations have been established in order to preserve a minimum of 90% of the gene diversity for each subspecies for 100 years. In order to make efficient use of currently available space and resources the *Tiger GCS* recommends a global minimal target population of 250 tigers in captivity for each of the five subspecies, and suggests how this number can be most satisfactorily distributed among various regional programs. *Minimum target population sizes* are defined as the smallest population size to meet the genetic and demographic objectives; actual population sizes in different regions may be much larger. This population size of 250 tigers for each subspecies will be sufficient to preserve 90% of the genetic diversity of each population for 100 years. Only studbook registered tigers will be managed within the *Tiger GCS*.

There are currently four regional programs that manage Sumatran tigers: the PKBSI program in Indonesia, the AZA Tiger Species Survival Plan (SSP) in North America, the EAZA Tiger European Endangered Species Program (EEP) in Europe, and the ARAZPA Australasian Species Management Plan (ASMP) in Australasia. The *Tiger GCS* recommends the continued maintenance of these existing programs for Sumatran tigers as follows:

Regional program	Current population	Minimum target population
Indonesia (PKBSI)	61	80
Europe (EEP)	104	75
North America (SSP)	57	70
Australasia (ASMP)	14	25
Total global captive population	*236*	*250*

Currently, only the European regional captive population has reached its minimum target size. Due to the relatively low number of breeding founders and unequal founder representation in these regional programs, only the North American population has maintained the regional and global goal of 90% genetic diversity retained. Sufficient founders are available in the Indonesian PKBSI Sumatran tiger program (as wild-caught problem tigers), but these potential founders need to reproduce and contribute offspring to the captive population. For the other three regional programs, additional founders from Indonesia will be needed to increase the founder base and genetic diversity of these captive populations. These regional programs are seeking to import unrelated Sumatran tigers which are surplus to the breeding needs of the PKBSI Sumatran tiger program (see regional report boxes).

Since the establishment of the *Tiger Global Conservation Strategy* substantial progress has been made in the development of an integrated and effective global captive management program for tigers. The primary task of the *Tiger GCS* and its representatives is to articulate the process and mechanisms by which linkage between *in situ* and *ex situ* tiger conservation programs can be achieved. It will then be their conservation mandate to do so.

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Current Status of the Sumatran Tiger EEP

Sarah Christie, Tiger EEP Coordinator

We have 49 male and 55 female tigers at 45 institutions in 10 countries.

This represents close to half of the total global managed population. All zoos bar one in Europe that hold Sumatran tigers participate in the EEP, and we have a 100% cooperation rate among participants. All transfers and all breedings (other than two accidental ones) for the last two years have been in accordance with EEP recommendations.

The EEP has 17 founders, but all except one are now dead.

The population has been managed since 1991; prior to this the pedigree became inextricably tangled, so all EEP Sumatran tigers, except for one male, are related to some extent to all other EEP tigers. Ongoing research (Mace and Christie, in prep.) indicates a significant negative effect of inbreeding on cub survival in this EEP. Inbreeding also results in loss of overall genetic diversity. Avoidance of inbreeding in this EEP is currently impossible in the majority of cases. Average inbreeding coefficient is 0.15, though current recommended pairings are producing cubs with inbreeding coefficients of below 0.1.

The EEP therefore needs new founder stock if it is to make the best possible contribution to the Global Conservation Strategy for the Sumatran Tiger.

Actual and potential genetic diversity in the Sumatran tiger EEP

	Actual GD	Potential GD
Current population	87.3%	93.6%
With two new founders and seven F1 offspring:	88.1%	95.1%
With two new founders, nine F1, & three F2 offspring:	89.2%	95.1%

Clearly, therefore, continued carefully managed breeding with the inclusion of two new founders would bring the Sumatran Tiger EEP up to, or over, the globally recommended target level of 90% retention of wild genetic diversity, and significantly lower levels of inbreeding in the population. The Sumatran Tiger EEP therefore requests that the PKBSI consider making two males available to the European tiger program.

The Sumatran Tiger EEP supports the PKBSI Sumatran Tiger Program;

by participating in captive workshops since 1992, and by raising funds to be spent on transfers of tigers between Indonesian zoos in accordance with the PKBSI program recommendations.

The Sumatran Tiger EEP supports the conservation of the Sumatran tiger in the wild;

By raising funds from Esso UK and other sources to fund the Sumatran Tiger Project in Way Kambas, and by organizing the UK Zoo Federation Tiger Week in 1996, which raised over US $37,000 for this project. London Zoo, which coordinates the Sumatran Tiger EEP, is now a partner in the Sumatran Tiger Project and will be funding the Tiger Rapid Evaluation Team of the Sumatran Tiger Project, which will conduct rapid evaluation of tiger status throughout Sumatra during 1997 and 1998. Funds for this are being raised from Esso UK and other sources and a down payment has already been made.

North American Sumatran Tiger Program

Gerald Brady, AZA Sumatran Tiger SSP Coordinator

The North American population currently stands at 57 individuals (29 males, 28 females) located at 25 zoos in the United States and one in Canada. There has been a breeding moratorium for 2 ½ years in order to sort out the genetic DNA data at the National Cancer Institute. The results show that the Sumatran tiger population in North America is stable, that no hybrids were found, and the breeding moratorium has been lifted.

Genetic analysis of the North American population indicates that 90% of the genetic diversity present in the original founders has been retained. The founder representation in the North American population needs to be increased substantially to maintain a viable program. The effective number of founders presently stands at eight in North America. A total effective number of 26 founders needs to be reached in order to fulfill the recommendations made by the AZA North American Sumatran Tiger Masterplan meeting held several years ago. This can only be accomplished by importing new individuals from the PKBSI zoos in Java and Sumatra. Presently, there are two major zoos in the United States, the San Francisco Zoo and the Dallas Zoo, that are able to finance one or more tigers each to import into the United States to reinforce the captive breeding program in North America.

Hopefully, with the help of the PKBSI zoo association and this masterplan workshop, a few individuals can be identified for North America. The AZA Tiger SSP will do whatever is necessary and essential to help the PKBSI with their tiger program and their continued success. Realizing that female tigers are extremely valuable within the PKBSI association, I would like to recommend that three males and only one female be identified for the North American program.

Please consider the information in this letter as merely suggestions and I recommend that you only make decisions that are appropriate for the well-being of the overall Sumatran tiger program.

Australasian Species Management Plan Report

David Pepper-Edwards, Sumatran Tiger ASMP Coordinator

The Tiger GASP workshop held in Edinburgh, Scotland in 1992 recommended that the Australasian region hold 25 Sumatran tigers, this being 10% of the captive population. Current regional planning commits to spaces for 27 tigers in ten zoos.

The Australasian Species Management Plan for Sumatran Tigers is presently under formal review although our primary goals remain the same. They are:

- To maintain a collection of genetically pure Sumatran tigers in the Australasian region, for exhibition and education purposes.
- To participate in a world captive breeding effort to conserve the genetic uniqueness of this subspecies.

Global tiger captive management program goals include the maintenance, for 100 years, of a captive population of *P.t. sumatrae* which represents greater than 90% of the genetic variation existing currently in wild populations.

The ASMP regional program aims to manage the Australasian population to articulate with other regional populations in accordance with this global target.

Regional Population Status

The ASMP population at 31 December 1996 increased by 1.2 births being reported from Wellington Zoo to 8.6.

Population Genetics

The regional population is descended from nine known founders. The regional population now represents 78.8% of the gene diversity predicted within the wild population.

Special Concerns

As a result of the comparatively small numbers of tigers to be maintained in this region, a periodic importation of new genetic material will be necessary in order to maintain a genetically viable population. Our immediate goal is 2.2 (two males, two females) unrelated animals.