



Conservation Breeding Specialist Group

Species Survival Commission
IUCN -- The World Conservation Union

U.S. Seal, CBSG Chairman

Memorandum of Cooperation to Develop a PKBSI Genome Resource Bank

At the 1994 PKBSI Sumatran Tiger Masterplan meeting it was agreed upon that because the need to support conservation of the Sumatran tiger as one of the protected species in Indonesia and stipulated in the *Indonesian Sumatran Tiger Conservation Strategy*, there is a need to develop a PKBSI Genome Resource Bank (GRB) for Sumatran tigers. The GRB, which is a repository of cryopreserved sperm (and eventually embryos), could be used as an option against losing more genetic variation from both captive and wild populations. Genetic diversity could be spread more effectively and efficiently among captive populations and between wild and captive populations by the transfer of genetic material. In the future, the GRB will provide options to increase gene diversity in isolated populations. Another future implication of a successful GRB and assisted reproductive program is that fewer animals would need to be maintained in zoos, thus increasing the capacity of zoos to provide space for the captive propagation of other species at risk of extinction.

The PKBSI GRB program must be systematically and scientifically managed under the guidance of the Indonesian scientific and management authorities to ensure that there is a positive conservation impact. It is for this reason that the IUCN/SSC Conservation Breeding Specialist Group (CBSG) has developed a GRB Action Plan for Siberian and Sumatran tigers in North American zoos. This Memorandum of Cooperation expands the plan to a global level by incorporating the Indonesian PKBSI. In the future CBSG intends to include all regional tiger zoo programs in this GRB global plan, which will be coordinated through the CBSG Tiger Global Animal Survival Plan (GASP). Indonesia is represented on the Tiger GASP Committee by the PKBSI Sumatran Tiger Co-Coordinator.

Therefore, this Memorandum of Cooperation indicates the PKBSI's willingness to work with CBSG to develop and complete a global *Genome Resource Banking Action Plan* for tigers.

Signed in Cisarua, February 10, 1995

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SUMATRAN TIGER Studbook

Page 1

Restricted to: (Panthera tigris sumatrae)

User Defined Fields: "PKBSI" \$ upper(SSP)

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Event	Birth-Origin	Rearing Name
528	F	28 May 1981	371	370	JAKARTA	28 May 1981	RAGUNI	Birth	Captive Born	Parent RAGUNI
532	M	26 Oct 1983	386	387	JAKARTA	26 Oct 1983	PEMUDA	Birth	Captive Born	Parent BAGUS
					TASIK	1 May 1985	PEMUDA	Transfer		
					YOGYAKARTA	21 Jan 1986	BAGUS	Transfer		
535	M	6 Nov 1983	371	370	JAKARTA	6 Nov 1983	NOPA	Birth	Captive Born	Parent NOPA/NOVA
543	M	10 Mar 1985	109	125	BREMERHVN	10 Mar 1985	UNK	Birth	Captive Born	Unknown COKLAT
					JAKARTA	19 Jan 1986	UNK	Transfer		
					BOGOR	17 Feb 1986	COKLAT	Transfer		
866	M	~ 1988	WILD	WILD	SUMATRA	~ 1989	HENDRA	Capture	Wild Born	Parent HENDRA
					BOGOR	3 Mar 1989	HENDRA	Transfer		
867	M	~ 1986	WILD1	WILD2	SUMATRA	~ 1987	GALUH	Capture	Wild Born	Parent GALUH
					BOGOR	8 Mar 1987	GALUH	Transfer		
868	M	~ 1986	WILD1	WILD2	SUMATRA	~ 1987	AGO	Capture	Wild Born	Parent AGO
					BOGOR	8 Mar 1987	AGO	Transfer		
869	F	~ 1989	WILD	WILD	SUMATRA	~ 1990	TERA	Capture	Wild Born	Parent TERA
					BOGOR	7 Aug 1990	TERA	Transfer		
870	M	~ 1988	WILD	WILD	SUMATRA	~ 1989	BAGIRA	Capture	Wild Born	Parent BAGIRA
					BOGOR	11 Apr 1989	BAGIRA	Transfer		
871	M	~ 1988	WILD	WILD	SUMATRA	~ 1989	BOKIR	Capture	Wild Born	Parent BOKIR
					BOGOR	1 Aug 1989	BOKIR	Transfer		
872	M	~ 1991	WILD	WILD	SUMATRA	21 Feb 1992	UNK	Capture	Wild Born	Parent BUKIT
					TAMAN	22 Feb 1992	UNK	Transfer		
					BOGOR	22 Jun 1992	BUKIT	Transfer		
873	F	~ 1971	WILD	WILD	SUMATRA	~ 1972	ELIS	Capture	Wild Born	Parent ELIS
					BOGOR	1 Jan 1972	ELIS	Transfer		
874	M	~ 1986	WILD	WILD	SUMATRA	~ 1987	MEDAN	Capture	Wild Born	Parent MEDAN
					BOGOR	16 Sep 1987	MEDAN	Transfer		
877	F	1 Dec 1978	875	876	BOGOR	1 Dec 1978	NENENG	Birth	Captive Born	Parent NENENG
878	M	1 Dec 1978	875	876	BOGOR	1 Dec 1978	UJANG	Birth	Captive Born	Parent UJANG

SUMATRAN TIGER Studbook

Restricted to: (Panthera tigris sumatrae)

User Defined Fields: "PKBSI" \$ upper(SSP)

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Event	Birth-Origin	Rearing Name
879	F	15 Jan 1991	867	877	BOGOR	15 Jan 1991	RAI	Birth	Captive Born	Parent RAI
880	F	15 Jan 1991	867	877	BOGOR	15 Jan 1991	RAKE	Birth	Captive Born	Parent RAKE
881	M	5 Nov 1992	867	877	BOGOR	5 Nov 1992	UCOK	Birth	Captive Born	Parent UCOK
882	F	5 Nov 1992	867	877	BOGOR	5 Nov 1992	BUTET	Birth	Captive Born	Parent BUTET
884	F	~ 1982	WILD	WILD	SUMATRA	????	UNK	Capture	Wild Born	Parent MANIS
					JAKARTA-P	~ 1983	UNK	Transfer		
					SEMARANG	17 Dec 1983	UNK	Transfer		
885	M	~ 1990	WILD	WILD	SUMATRA	????	UNK	Capture	Wild Born	Parent KULU
					JAKARTA-P	????	UNK	Transfer		
					JAKARTA	8 Sep 1991	KULU	Transfer		
886	M	19 May 1985	371	528	JAKARTA	19 May 1985	RETNI	Birth	Captive Born	Parent KUBU
					YOGYAKARTA	19 May 1987	RETNI	Transfer		
					SURABAYA	1 Aug 1987	KUBU	Transfer		
887	F	19 May 1985	371	528	JAKARTA	19 May 1985	RETNO	Birth	Captive Born	Parent RICANA
					TASIK	~ 1986	RETNO	Transfer		
					YOGYAKARTA	21 Jan 1986	RICANA	Transfer		
895	M	1 Sep 1989	535	528	JAKARTA	1 Sep 1989	RAMA	Birth	Captive Born	Parent RAMA
896	M	1 Sep 1989	535	528	JAKARTA	1 Sep 1989	TONY	Birth	Captive Born	Parent TONY
897	M	15 Mar 1990	535	528	JAKARTA	15 Mar 1990	RAMBO	Birth	Captive Born	Parent RAMBO/RIMB
898	F	15 Mar 1990	535	528	JAKARTA	15 Mar 1990	RAMBI	Birth	Captive Born	Parent RAMBI
904	M	14 Jul 1991	535	528	JAKARTA	14 Jul 1991	RANGGA	Birth	Captive Born	Parent RANGGA
					JAMBI	18 Jun 1993	RANGGA	Transfer		
905	M	4 Feb 1992	535	528	JAKARTA	4 Feb 1992	ERICK	Birth	Captive Born	Parent ERICK
906	F	4 Feb 1992	535	528	JAKARTA	4 Feb 1992	SELLA	Birth	Captive Born	Parent SELLA
					JAMBI	18 Jun 1993	SELLA	Transfer		
908	F	~ 1986	WILD	WILD	SUMATRA	~ 1986	UNK	Capture	Wild Born	Unknown DELI
					YOGYAKARTA	~ 1987	DELI	Transfer		
					SURABAYA	1 May 1987	DELI	Transfer		
909	M	9 Feb 1989	886	908	SURABAYA	9 Feb 1989	COLDRE	Birth	Captive Born	Parent COLDREN

SUMATRAN TIGER Studbook

Restricted to: (Panthera tigris sumatrae)

User Defined Fields: "PKBSI" \$ upper(SSP)

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Event	Birth-Origin	Rearing Name
910	F	9 Feb 1989	886	908	SURABAYA	9 Feb 1989	MARRY	Birth	Captive Born	Parent MARRY
912	M	15 Jun 1990	886	908	SURABAYA	15 Jun 1990	MELCOL	Birth	Captive Born	Parent MELCOLM
					SOLO	3 May 1993	MELCOL	Transfer		
913	F	15 Jun 1990	886	908	SURABAYA	15 Jun 1990	ALTEA	Birth	Captive Born	Parent ALTEA
915	M	19 Jul 1992	886	908	SURABAYA	19 Jul 1992	BRITIS	Birth	Captive Born	Parent BRITISH
916	M	19 Jul 1992	886	908	SURABAYA	19 Jul 1992	NELLY	Birth	Captive Born	Parent NELLY
934	F	27 Jul 1989	532	917	YOGYAKARTA	27 Jul 1989	TIPUK	Birth	Captive Born	Unknown TIPUK
935	M	16 Nov 1989	532	887	YOGYAKARTA	16 Nov 1989	BALADE	Birth	Captive Born	Parent BAGUS
					MEDAN	28 Mar 1992	BAGUS	Transfer		
940	F	3 Jan 1991	532	887	YOGYAKARTA	3 Jan 1991	SRIKAN	Birth	Captive Born	Unknown SRIKANDI
941	F	3 Jan 1991	532	887	YOGYAKARTA	3 Jan 1991	ARIMBI	Birth	Captive Born	Unknown ARIMBI
942	M	8 Feb 1992	532	887	YOGYAKARTA	8 Feb 1992	BUDI	Birth	Captive Born	Unknown BUDI
					BANDUNG	3 Oct 1996	BUDI	Transfer		
943	F	8 Feb 1992	532	887	YOGYAKARTA	8 Feb 1992	LISA	Birth	Captive Born	Unknown LISA
					SOLO	1 Jul 1993	LISA	Transfer		
945	M	29 Jan 1993	535	528	JAKARTA	29 Jan 1993	VIGO	Birth	Captive Born	Parent VIGO
953	F	21 May 1993	532	887	YOGYAKARTA	21 May 1993	WAGE	Birth	Captive Born	Parent WAGE
					BANDUNG	3 Oct 1996	WAGE	Transfer		
954	M	21 May 1993	532	887	YOGYAKARTA	21 May 1993	KLIWON	Birth	Captive Born	Parent KLIWON
T9590	F	~ 1992	WILD	WILD	SUMATRA	16 Nov 1992	UNK	Capture	Wild Born	Parent CANE
					BOGOR	1 Jan 1993	CANE	Transfer		
T9595	M	13 May 1993	886	908	SURABAYA	13 May 1993	BONNIE	Birth	Captive Born	Parent BONNIE/BON
T9596	F	13 May 1993	886	908	SURABAYA	13 May 1993	MELLY	Birth	Captive Born	Parent MELLY/MELI
T9600	F	25 Jun 1993	909	910	SURABAYA	25 Jun 1993	JUSMI	Birth	Captive Born	Parent JUSMI/JASM
T9601	F	25 Jun 1993	909	910	SURABAYA	25 Jun 1993	JUSNI	Birth	Captive Born	Parent JUSNI/JUNI

SUMATRAN TIGER Studbook

Restricted to: (Panthera tigris sumatrae)

User Defined Fields: "PKBSI" \$ upper(SSP)

Stud #	Sex	Birth Date	Sire	Dam	Location	Date	Local ID	Event	Birth-Origin	Rearing Name
T9603	M	6 Nov 1983	371	370	JAKARTA	6 Nov 1983	NOPI	Birth	Captive Born	Parent NOPI/NOVI
					SEMARANG	3 Dec 1996	NOVI	Transfer		
T9613	M	15 May 1994	535	528	JAKARTA	15 May 1994	SEMI	Birth	Captive Born	Unknown SEMI
T9614	F	15 May 1994	535	528	JAKARTA	15 May 1994	CHIKA	Birth	Captive Born	Unknown CHIKA
T9615	M	~ 1994	WILD	WILD	SUMATRA	8 Jan 1995	UNK	Capture	Wild Born	Unknown
					TAMAN	18 Jan 1995	UNK	Transfer		
					SURABAYA	~ Mar 1997	UNK	Transfer		
T9621	F	~ 1987	WILD	WILD	SUMATRA	~ 1996	UNK	Capture	Wild Born	Unknown LADY
					BOGOR	8 Oct 1996	LADY	Transfer		
T9622	F	~ Jan 1996	WILD	WILD	SUMATRA	~ Jul 1996	UNK	Capture	Wild Born	Unknown TARI
					BOGOR	17 Oct 1996	TARI	Transfer		
T9625	M	~ 1995	WILD	WILD	SUMATRA	~ 1995	UNK	Capture	Wild Born	Unknown SIMBA
					JAKARTA-P	~ 1995	SIMBA	Transfer		
					BOGOR	24 Jan 1997	SIMBA	Transfer		
T9627	F	10 Sep 1996	886	908	SURABAYA	10 Sep 1996	SEPTI	Birth	Captive Born	Unknown SEPTI
T9628	F	10 Sep 1996	886	908	SURABAYA	10 Sep 1996	HESTI	Birth	Captive Born	Unknown HESTI
T9629	F	????	WILD	WILD	SUMATRA	~ Feb 1997	UNK	Capture	Wild Born	Parent
					MEDAN	12 Feb 1997	UNK	Transfer		

TOTALS: 32.29.0 (61)

AZA Field Conservation Resource Guide

Training, Transferring Technology, and Linking *In Situ* and *Ex Situ* Tiger Conservation in Indonesia

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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).

In late 1991 the status, distribution and threats of the wild Sumatran tiger population were largely unknown. 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. There was no plan for wild Sumatran tigers other than the same one that led to the demise of the Javan tiger.

The status of the captive Sumatran tiger population in 1991 showed more promise but was far from secure. 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 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*, and wild-caught tigers were not optimally utilized, even though new genetic founders were greatly needed outside of Indonesia.

The precarious status of the Sumatran tiger in the wild and its mismanagement in captivity called for immediate action in Indonesia. Initial contact was made by the American Zoo and Aquarium Association (AZA) Tiger Species Survival Plan (SSP) with Taman Safari Indonesia and Ragunan Zoo, who then contacted PKBSI to develop an Indonesian zoo-based captive management program for this 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. Concurrently, the AZA Tiger SSP approached the Indonesian forestry department (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, forestry and international conservation authorities involved with tiger conservation in Indonesia. In less than five years time, Indonesia has put in place well-developed *ex situ* and *in situ* programs linked by a national conservation strategy for this species. The projects and processes outlined here describe the process and may serve as one 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 Table 1).

Development of Indonesia's Captive Management Program

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.

Captive Management Workshop

A preliminary training and master planning 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 master plan. 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, 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 Surakarta in Solo; Timjomoyo in Semarang; Kebun Binatang Surabaya in Surabaya; Griya Satwa Mulya in Medan, Sumatra; and 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). 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 master plan. 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.

Sumatran Tiger Master Plan

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 master plan 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 PKBSI 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.

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 an initial Master Plan (Daryadi et al., 1998) has been drafted for the cooperative management of Sumatran tigers in Indonesia. 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.

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, funded by the AZA's Big Cat Survival Fund. 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).

Sumatran Tiger Project

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).

Long-term field study: A four-year study of tiger biology and human-tiger interactions was initiated at Way Kambas National Park in southern Sumatra in 1995. The tiger field ecology component uses cutting-edge remote infra-red camera and Global Positioning System (GPS) technology as well as traditional field ecology methods to establish tiger densities, habitat requirements, life history characteristics, prey type and density, and other ecological information necessary to assess population viability (Franklin et al, in press).

Rapid evaluation of tigers and habitat: Current information about tiger distribution and threats is limited and based on scattered and unconfirmed reports. Formal conservation and management plans cannot be implemented without better information on the distribution and status of tiger populations. Rapid Evaluation Teams, funded by the Zoological Society of London, will use methods learned at Way Kambas to gather information on presence or absence of tigers, potential habitat, available prey species, extent and type of threats from surrounding villages, potential poaching pressure, and existing conservation efforts throughout Sumatra. This information is being collected in a large computerized Geographic Information System (GIS) database that will allow conservation planners and managers to easily access and study the results of these efforts.

Community-based conservation: The community conservation component (supported by the *Save the Tiger Fund* and the *Rhino and Tiger Fund*) uses rapid village assessments and detailed surveys to study land use patterns, human-wildlife conflicts, and attitudes of villagers living near the park (Nyhus et al., in press). Data and results from the long-term and rapid studies of tigers and human-tiger interactions are being used to develop community-based education programs in forest-edge communities near tiger protected habitats. The first tiger education program, with support from a regional university and government authorities, is taking place in villages near

Way Kambas National Park and includes meetings with local community leaders and PHPA officials, development of appropriate conservation awareness material, and several tiger-related programs. Training programs for PHPA staff from across the island is also planned to address basic issues related to collecting information about tigers and threats to tigers and their habitat.

Linking *Ex Situ* and *In Situ* Conservation

The long-range goal of the *PKBSI Sumatran Tiger Master Plan* (Manansang et al., 1997) 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. This year a brochure produced jointly by PHPA and PKBSI and funded by Australian agencies was produced and distributed to the ten zoos in Sumatra and Java that have tigers. Additional 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.

Zoos as Sources of Funding and Support

In addition to their role as centers for education and research, zoos can provide financial and technical support to field conservation programs. The Sumatran Tiger Project, for example, is a field conservation project with primary support from institutions with a traditional focus on captive animals. The Project Director is the Director of Conservation at the Minnesota Zoo, and the primary Indonesian sponsor is the Managing Director of Taman Safari Indonesia. The UK Federation of Zoos, London Zoo and the Zoological Society of London (ZSL) have played an important role in helping to raise funds for components of this project. In general, relatively urban and high profile zoos can provide infrastructure support, increased visibility and awareness, and help raise funding otherwise unavailable to isolated or long-term field conservation initiatives (Tilson and Christie, in press).

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.

Guidelines for Starting a Program

In today's world, the concept of the inadequacy of the "zoo ark" is well established, and it is imperative that the responsibility of conserving endangered species is with the country where that species lives. Our role as responsible conservators is to assist these countries in their efforts, and if we emphasize the critical need to link *ex situ* development with *in situ* conservation, we will be more successful in the long run. The following guidelines are suggested for initiating such programs in Indonesia, but have some applicability across Asia (also see Nyhus et al., this volume).

Before directly contacting PHPA, local contact should be made with one of the PKBSI zoos or one of the official conservation NGOs working in Indonesia in order to establish first, the conservation need, and second, the process by which any captive management and/or field conservation program can be initiated. In addition to the zoo directors at any of the PKBSI zoos, interested parties could also contact the President of the Indonesian Zoological Parks Association (PKBSI) based in Jakarta. Before beginning, it is appropriate that these programs be coordinated or acknowledged by the relevant SSP or Taxon Advisory Group (TAG) as well as the Faunal Interest Group (FIG) of the AZA.

Careful consideration should be taken in the selection of species or ecosystem on which to concentrate. Again, a focus on charismatic "umbrella species" can garner more financial support and reap greater ecological benefits in *ex situ* conservation programs. Unless the distribution and status of the species under consideration is well established within Indonesia, PHPA will probably insist that some form of wild population assessment be conducted, such as a Conservation Assessment and Management Plan (CAMP) for a broad taxonomic group, or a Population and Habitat Viability Assessment (PHVA) for a single species.

Once the conservation needs are established and if captive programs are considered essential, the next step is to develop and implement recommendations in cooperation with PKBSI zoos to the extent possible with available resources. Each program will vary according to species needs, but all will have some combination of staff training, infrastructure support, and technology transfer. Every program needs to address Indonesian expectations, which include that: 1) the program first fulfill the conservation needs of Indonesia before extraction of surplus animals can be considered; and that 2) Indonesian staff be trained to manage the programs themselves and make their own decisions.

When considering the initiation of such a program, an institution must evaluate the level of commitment it is prepared to make, not only in terms of funds but also in terms of staff, time and travel. Often ongoing, long-term support is necessary to make a program successful and bring it to fruition. Assistance cannot be provided via long-distance communications, but supporters need to travel to the range country and participate directly. Funding and expertise needs are

likely to be greater than what a single institution can provide, but the involvement of multiple sponsors and funding sources means the pooling of resources which can spawn significant conservation action (also see Tilson and Sriyanto, this volume).

When providing assistance to agencies in other countries, one must be cognizant of differences in social customs and formalities, political hierarchies with government agencies, cultural perceptions, and similar difficulties (Nyhus et al., this volume). Language barriers alone can present significant difficulties and misunderstandings. Knowledge and sensitivity in these areas will facilitate a successful program.

At the outset of developing a conservation program in Indonesia or another range country, it is important to assess the status and needs for both *in situ* and *ex situ* conservation efforts and to develop a plan of action to meet those needs. It is also important, however, to remain flexible in the execution of this plan. Actions which may seem logical or appropriate to us may not be so straight-forward to range country managers with differing goals and philosophies of conservation management and resource utilization. The bottom line is to remember that it is *their* program, not ours, to manage, and our role is to assist wherever possible and feasible in that process.

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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).

	<u>Ex Situ Programs</u>	<u>In Situ Programs</u>
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 <i>Indonesian Sumatran Tiger Conservation Strategy</i> (Minnesota Zoo)
January 1995	Training in remaining zoos Tiger/facility evaluations Preliminary Master Plan meeting (AZA Ralston Purina CEF)	Donation of "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 Master Plan (Save the Tiger Fund, Minnesota Zoo) Conservation education brochure (Australian Commonwealth EPA, ARAZPA, Zool. Parks Board of NSW)	Publication of bilingual edition of tiger conservation strategy (ESSO Indonesia)
June 1997		Initiation of Rapid Evaluation Teams (Zoological Society of London) Formation of Tiger Steering Committee

International co-operative efforts to save the Sumatran tiger

Panthera tigris sumatrae

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The Endangered status of the Sumatran tiger *Panthera tigris sumatrae* is now well recognized around the world, with an estimated population of 400–500 remaining in the wild and c. 245 Sumatran tigers maintained *ex situ*. In recognition of the situation, the Indonesian government has prioritized the steps necessary for effective conservation of the subspecies, formalized in 1994 in the Ministry of Forestry's far-sighted document, the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994). This document inspired the initiation of a multitude of programmes, which evolved into a multi-national conservation effort to save the Sumatran tiger, involving the World Conservation Union specialist groups, zoological parks, universities, governments and corporations working co-operatively with Indonesian forestry and wildlife agencies. In this article, we illustrate how the traditionally isolated fields of *ex situ* (zoos and captive management) and *in situ* conservation (wildlife agencies and field programmes) can work together. In today's world close co-operation of workers in these two fields will become increasingly necessary for effective conservation action.

Key-words: conservation, *in situ*, Indonesia, international co-operation, Sumatran tiger

According to the World Conservation Union (IUCN), the Sumatran tiger *Panthera tigris sumatrae* is Critically Endangered (Santiapillai & Ramono, 1987; Tilson, Foose *et al.*, 1993; Ramono & Santiapillai, 1994; Tilson, Soemarna *et al.*, 1994). About 400 Sumatran tigers survive in five Indonesian national parks and two game reserves and another 100 tigers live in unprotected areas that are scheduled to be converted to agriculture. Tigers are still poisoned by forest-edge villagers, unknown levels of poaching occur (Tilson & Traylor-Holzer, 1994) and forest loss or disturbance has further fragmented these populations. The largest estimated population of about 110 tigers occurs in North Sumatra in Gunung Leuser National Park (Griffiths, 1994); the remaining populations are estimated at half this number or fewer (Faust & Tilson, 1994). These small populations are extremely vulnerable to poaching or removal of problem

tigers by Indonesian wildlife officials (Seal *et al.*, 1994). Even without any further losses, present populations are so small that they are vulnerable to severe environmental catastrophes, as well as to the demographic and genetic problems typical of small populations. Isolated and fragmented populations need interactive management strategies to ensure their long-term viability (Wiese *et al.*, 1994; Conway, 1995).

To address the declining status of the Sumatran tiger, the Indonesian Ministry of Forestry, through the Directorate General of Forest Protection and Nature Conservation (PHPA), drafted a set of recommendations in the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994). The objective was to develop and sustain a conservation programme in Indonesia that will ensure the long-term viability of wild Sumatran tigers. In part, this strategy was based upon the results of a Population and Habitat Viability Analysis (PHVA) held in 1992 for wild tiger populations, which included an action plan with short- and long-term goals for PHPA (Sumardja *et al.*, 1994) and a draft Master Plan of the Indonesian Zoological Parks Association/Perhimpunan Kebun Binatang Se-Indonesia (IZPA/PKBSI) for captive tiger populations.

The *Indonesian Sumatran Tiger Conservation Strategy* is comprised of four general categories of recommendations and priorities, each with multiple and often overlapping components, to ensure the long-term survival of Sumatran tigers throughout their remaining range. These categories involve: (1) absolute protection of wild tiger populations and habitats; (2) interactive management strategies for wild populations at risk; (3) captive management for reinforcement and recovery of wild populations; (4) creation of a communication and infrastructure network to develop conservation education and awareness programmes throughout Indonesia and to co-ordinate

all aspects of the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994).

Both *ex situ* and *in situ* Indonesian agencies will be implementing the *Indonesian Sumatran Tiger Conservation Strategy*. The *ex situ* component is responsible for the development of a managed captive population of Sumatran tigers and a genome resource bank for the reinforcement and recovery of the wild populations. The *in situ* component is primarily responsible for programmes to protect wild tiger populations and their habitat, to develop interactive management strategies for these populations and to conduct conservation education programmes for forest-edge villagers in proximity of wild tigers.

In this paper we briefly summarize the *ex situ* components of the strategy, primarily the development of a Master Plan for Sumatran tigers under the aegis of the PKBSI, and their connection to *in situ* programmes under the control of PHPA. The PKBSI Sumatran tiger Master Plan (Tilson & Traylor-Holzer, 1993) was created following three assessment and training sessions conducted in Indonesia by an international team of specialists on tigers in zoos representing: (1) the American Zoo and Aquarium Association (AZA) Tiger Species Survival Plan (SSP), (2) the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA) Australasian Species Management Programme (ASMP) and (3) the European Association of Zoos and Aquaria (EAZA) European Endangered Species Programme (EEP). At the same time PHPA was developing programmes for wild populations of Sumatran tigers. A PHVA workshop using the Geographic Information System and field information from PHPA (Faust & Tilson, 1994) outlined the spatial fragmentation and status of tiger populations in Sumatra. In 1994 PHPA drafted the *Indonesian Sumatran Tiger Conservation Strategy*, which set the guidelines for long-range plans for via-

bility of Sumatran tigers. Several recommendations are currently being implemented, including initiation of a field study of Sumatran tigers in Way Kambas National Park in south-eastern Sumatra (Tilson & Franklin, 1995; Bastoni, 1996; Sriyanto, 1996; N. Franklin, unpubl. data) and community-based education programmes for forest-edge villagers around the parks (Nyhus & Tilson, 1995).

EX SITU PROGRAMMES

The precarious status of the Sumatran tiger in the wild called for the immediate initiation of a captive-management programme for the subspecies in Indonesia. One of the first steps was to design and construct an *ex situ* captive-breeding facility. Because the Indonesian government had already designated Taman Safari Indonesia (TSI) as the Indonesian Center for the Reproduction of Endangered Wildlife, it was viewed as the most appropriate site and was designated by the Directorate General of PHPA as the official repository for wild-caught tigers from Sumatra, including all problem animals. The breeding facility is large enough to maintain four or more breeding pairs of tigers and at time of writing holds five wild-caught animals. In April 1995 the first recommended breeding resulted in one surviving cub.

The international team of specialists on captive tigers visited nine of the ten Indonesian zoos: Taman Safari Indonesia in Cisarua; Kebun Binatang Ragunan in Jakarta; Gembira Loka in Yogyakarta; Kebun Binatang in Bandung; Satwa Taru Surakarta in Solo; Timjomoyo in Semarang; Kebun Binatang in Surabaya; Griya Satwa Mulya in Medan; Kebun Binatang in Jambi. The tenth zoo, Kebun Binatang in Bukittinggi, does not maintain tigers. Significant accomplishments were made during the assessments and staff training programmes (reviewed in Tilson, Manansang *et al.*, in press.).

1. Between 1992 and 1995 the team visited nine zoos in Java and Sumatra, and provided hands-on training, for over 150 staff, that focused on the correct procedures for medical treatment, immobilization, immunization, evaluation, health maintenance and husbandry.

2. During the project, 51 of the 57 tigers maintained in Indonesian PKBSI programme were evaluated: of the remaining six animals two were too old (>23 years) and four were too young. All tigers were given physical examinations that included blood collection (for blood cell counts and serum chemistry) and tissue biopsy collection (for genetic evaluation). Each animal was permanently tattooed with a temporary or permanent studbook number and a transponder was placed under the skin for back-up identification. In addition, six tigers received dental treatment.

3. During the project, enclosure facilities, animal management procedures and policies, diets and daily record keeping were evaluated for all nine zoos and recommendations were made to update the PKBSI Sumatran tiger Master Plan.

4. A PKBSI genome resource bank (GRB) was established at Taman Safari Indonesia and semen from 14 tigers is stored there. Blood serum samples collected from 54 tigers, to be used for screening for disease and for making comparisons between wild-caught and captive-born animals, and skin biopsies and hair samples collected from 52 tigers to initiate a molecular DNA library (for example, for subspecies discrimination), are also held at the genome resource bank. A Memorandum of Cooperation indicating '...the PKBSI's willingness to work with CBSG to develop and complete a global Genome Resource Banking Action Plan for tigers' has been signed by representatives from the PKBSI, the IUCN/SSC CBSG and PHPA.

5. The PKBSI Sumatran tiger Master Plan meeting was held in February 1995 and attended by key staff from the nine

PKBSI zoos as well as the PHPA, which maintains ownership of all Sumatran tigers in Indonesia. It was recommended that the Master Plan should reflect conservation priorities outlined in the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994).

6. A regional studbook for Indonesian Sumatran tigers was approved. This involved training staff to use the International Species Information System (ISIS) computer software programs (ARKS and SPARKS), the appointment of an Indonesian studbook keeper, the compilation of data and records from Indonesian zoos to form the studbook database and the permanent identification and registration of all studbook registered Sumatran tigers. All tigers in the PKBSI programme have now been assigned either a temporary or permanent studbook number. To ensure positive identification this number was tattooed on the inside thigh of each animal during immobilization. A transponder was inserted under the skin at the shoulder and the transponder number was recorded in the studbook and in the tiger's permanent records. These measures ensure that there is no ambiguity about the identity of any individual animal.

7. An Indonesian version of the AZA Tiger SSP husbandry manual was produced and made available to all PKBSI zoos in both English and Bahasa Indonesia (Tilson, Brady *et al.*, 1994).

Indonesian zoos are now building upon these initial efforts. When the programme is established it will ensure the maintenance of a secure captive population that can contribute to the survival and recovery of wild tiger populations in Sumatra. The Indonesian programme is designed to interact globally with other programmes in Australasia (ASMP), Europe (EEP) and North America (SSP) as part of the IUCN/SSC CBSG Tiger Global Animal Survival Plan (GASP), which ranks the transfer of information

and technology as a high priority for regional programmes (Tilson, Foose *et al.*, 1993).

IN SITU PROGRAMMES

There are three interconnected issues that concern the long-term survival of wild populations in Sumatra: (1) what are the key life-history characteristics of wild tigers; (2) how should the remaining small populations be monitored through time; (3) how should human-tiger conflicts be resolved? The PHPA has only basic knowledge of the status, distribution and threats that face tigers throughout Sumatra and before decisive management strategies can be formulated, more specific information, regarding these three issues, needs to be validated.

Wild tiger biology Carefully planned field studies, such as Bastoni (1996), Sriananto (1996) and Tilson & Franklin (1995), are needed to determine the biology and life history of the subspecies and its relationship to the habitat and prey base. Without this information, it would be difficult to develop effective interactive management strategies, which are the only way to keep wild populations viable. In June 1995 field studies were established in Way Kambas National Park. The Indonesian Institute of Sciences has officially approved the project and the Indonesian Ministry of Forestry, the official collaborating agency with Taman Safari Indonesia, has signed a Memorandum of Understanding endorsing the project. A base camp has been established in the middle of Way Kambas National Park and in November 1995 the first wild tiger of the project was photographed and identified.

Some of the initial tasks of the ongoing field study are: (1) to estimate the distribution and density of tigers and their prey using radio-telemetry, remote camera surveys and direct observations, and to evaluate the cost and effectiveness of each technique; (2) to determine more precise

information on life-history characteristics, mean litter size, neonatal mortality rates, spacing patterns in lowland forests, causes of mortality and evidence of fragmentation into sub-populations; (3) to collect blood serum, tissue biopsies and semen when tigers are immobilized for the fitting of radio-collars. These samples will enable disease evaluations and genetic profiles to be developed as well as providing reference materials for use in future DNA analysis and assisted reproductive techniques; (4) to train PHPA and university counterparts involved in the projects to become future conservation leaders in Indonesia; (5) to integrate results from the above tasks into a feasible model that can be expanded for evaluating tiger populations living elsewhere, specifically in mountainous sub-montane forests of Kerinci Seblat and Bukit Barisan Selatan National Parks.

In April 1996, a 162 km² site was identified that could be used for the long-term monitoring of a core population of tigers. A systematic census of the animals in this area was carried out using 20–30 remote infra-red cameras. Over 4000 photographs have been catalogued and over 50 of these are of tigers. Six animals have been positively identified as living at this site. A second 100 km² site has been identified in the south-east corner of Way Kambas National Park. Tracks of three adult ♂♀ with attending cubs have been seen. One tiger was observed attacking a herd of Asian elephants *Elephas maximus* in an attempt to kill a young cow.

A systematic evaluation of prey species and habitat preference indicates that large species, such as Sambar *Cervus unicolor*, Wild boar *Sus scrofa* and Indian muntjak or Barking deer *Muntiacus muntjak*, are probably the most common prey items. Other small predators have been photographed using the same trails as the tigers, such as Temminck's or Asiatic golden cats *Catopuma temminckii*, Leopard cats *Prionailurus bengalensis*, Marbled cats *Pardofelis marmorata*, Flat-headed cats

Prionailurus planiceps and at least four species of civets, including Masked palm civet *Paguma larvata*, Banded palm civet *Hemigalus derbianus*, Malay civet *Viverra zangalunga* and Otter civet *Cynogale bennettii*.

Long-term monitoring of wild tigers Tigers are extremely difficult to census because they are secretive and they avoid contact with humans whenever possible. Even in places where tigers are censused regularly, such as in the reserves in India, numbers vary significantly from year to year. Estimates are often based upon the identification of individual tiger tracks and the reliability of this technique is doubtful. In Indonesia the national parks are huge and some areas are practically inaccessible with low overall prey densities and correspondingly low tiger densities. Remote camera censusing has provided reasonable estimates of tigers in two areas of Gunung Leuser National Park (Griffiths, 1994). The scope of this promising technique needs to be expanded and evaluated as a tool for long-term monitoring of tiger populations (Bastoni, 1996).

Once a standardized field censusing methodology for tiger prey is established in Way Kambas National Park, additional census teams need to validate the presence or absence of tigers in other protected areas of Sumatra. Some of the tasks of this programme, which began in the second quarter of 1996, are: (1) to record observations of tigers, from photographs and signs (footprints, faeces and scrapings), and their prey on standardized forms, using Global Positioning System units and Geographic Information System-generated maps; (2) while conducting censuses, to report any instances of poaching to PHPA. As yet there is no evidence of tiger poaching in the Way Kambas National Park. Illegal entry and activities have been confined to fishermen, collectors of aromatic resin and villagers cutting grass for their livestock.

Resolving human-tiger conflicts An evaluation of forest resources required by both the human and tiger populations, and human attitudes towards local conservation ideas needs to be made before conflicts can be resolved. The PHPA is vague on how the loss of tigers, through poaching, poisoning and official removal of problem animals, impacts wild populations and yet this is one of the most critical issues affecting tiger viability in the wild. Human growth trends in villages adjacent to protected areas need to be evaluated in relation to how their activities may or may not impact forest resources in the future (Nyhus & Tilson, 1995).

Official records over the last 10 years show that, on average, tigers kill two people per year in Sumatra. In April 1995, a villager was killed while collecting grass c. 15 km from where the field study base camp is located. A community-based conservation education programme will be used to evaluate human-wildlife interactions and co-ordinate education of forest-edge villagers. The programme will be used to evaluate local attitudes and perceptions towards the resources in Way Kambas National Park, to investigate how local communities use and interact with the resources, and to monitor the effectiveness of conservation awareness and education programmes in the area which support long-term efforts to conserve remaining populations of tigers and other species, such as Sumatran rhinoceros *Dicerorhinus sumatrensis* and Asian elephants.

Some initial evaluations are under way to: (1) model human population growth and land-use trends adjacent to Way Kambas National Park and evaluate their potential impact on the future viability of resident tigers; (2) evaluate human attitudes towards tigers and develop effective education programmes to engender local support for tiger conservation, including ecotourism in Way Kambas National Park and the development of effective lit-

igation in human-tiger interactions; (3) develop standardized 'rapid assessment' methodologies of human attitudes and forest resources for use in evaluating human-tiger conflicts in other areas of Sumatra.

In April 1996, community meetings and field surveys were carried out in ten villages in three different districts along the south-eastern perimeter of Way Kambas National Park. Global Positioning System units and passive infra-red monitoring units will be used to monitor and estimate the extent of human activities.

INTERNATIONAL CO-OPERATION

Close co-operation between *ex situ* and *in situ* conservation will be critical if the Sumatran tiger is to be saved. Zoos can contribute towards conservation of species, far beyond their traditionally perceived role as educators or managers of captive programmes for endangered species (Koontz, 1996; Wallis, 1996), through: (1) the transfer of technology through the training of range country workers (Woodside & Kelly, 1995; Tilson, Manansang *et al.*, in press); (2) contribution of funds supporting field programmes (Hutchins & Wiese, 1991; Conway, 1995; Tilson, 1995, in press); (3) joint *in situ* and *ex situ* activities (Tilson, Garland & Phipps, 1993).

Australasian co-operation The Australasian Commonwealth Environmental Protection Agency, the Zoological Parks Board of New South Wales and ARAZPA presented PHPA and PKBSI with a Sumatran Tiger Rescue Kit. This kit contains all the equipment and supplies necessary to capture problem tigers which can then be incorporated into the conservation programme. This is an alternative to killing tigers which pose a risk to people. Funds are also being provided for publication of conservation education materials for distribution in Indonesia.

In March 1995 the Zoological Parks Board of New South Wales, through Tar-

onga Zoo, Sydney, and Western Plains Zoo, Dubbo, provided the Indonesian studbook keeper with funds to travel to Sydney to attend the Australasian Species Management Training School (Woodside & Kelly, 1995). Other travel funds for in-country expenses were provided by the Asian Tiger Fund at Minnesota Zoo.

Additional conservation programmes are being considered by ARAZPA in partnership with Esso Australia, including small grants for field-study support, community-based conservation education internships and programmes, and support for the PKBSI-based zoo training programmes.

American Zoo and Aquarium Association The initiation of conservation programmes for Sumatran tigers began with the Population and Habitat Viability Analysis and the development of the PKBSI Sumatran tiger management programme. Over a period of 3 years three workshops were supported by the AZA Conservation Endowment Fund's Ralston Purina Big Cat Survival Fund through Minnesota Zoo. Taman Safari Indonesia supported the in-country costs, including the labour costs, while the tiger breeding facility itself was supported by contributions from 18 AZA member zoos. The Sumatran tiger management programme has provided PKBSI with prototypes for developing captive-management programmes for other threatened species in Indonesia.

Save the Tiger Fund The partnership between the Exxon Corporation and the National Fish and Wildlife Foundation supports a multitude of conservation programmes across Asia and in zoos worldwide (Pitts, 1995), including the support of a long-term field study of Sumatran tigers in Way Kambas National Park through a grant to Minnesota Zoo. Funding is also being provided for a community-based conservation education programme and the development of

Geographic Information System-based maps of tiger habitat in Sumatra. Additional support for the Sumatran Tiger Project is provided by Esso UK, through London ZSL, and Esso Indonesia, through Taman Safari Indonesia.

The Save the Tiger Fund is providing funds to supply the PKBSI zoos with tiger immobilization kits and to hold a PKBSI Sumatran tiger Master Plan meeting, both co-ordinated by Taman Safari Indonesia.

The Zoological Society of London London ZSL has supported the costs of their staff attendance at the workshops and currently supports the field study by funding a field site reconnaissance and providing small grants for purchasing field equipment. Additional equipment needs are being considered for 1996. The transfer of tigers between Indonesian zoos, as recommended by the Master Plan, may also be funded.

The Federation of Zoological Gardens of Great Britain and Ireland A Tiger Week will be held in May 1996 to raise funds for three projects, including the Sumatran tiger field study in Way Kambas National Park.

Conservation Breeding Specialist Group of the IUCN/SSC Co-ordination of workshops and support for the implementation of the Tiger GASP (through Minnesota Zoo), the genome resource bank and the CBSG Indonesian Program located at Taman Safari Indonesia.

Taman Safari Indonesia is the critical link between PKBSI *ex situ* programmes and PHPA *in situ* programmes, including co-ordination of the PKBSI Sumatran tiger programme, the breeding facility, the genome resource bank, the regional studbook and the secretariat for the field study. Taman Safari Indonesia also serves as a collaborating institution, along with PHPA and the CBSG Tiger GASP, of the field study.

Conservation programmes for tigers supported by Esso Indonesia, through Taman Safari Indonesia, include providing funds to PHPA for the translation of the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994) into Bahasa Indonesia and for the publication and distribution of the Indonesian version to appropriate agencies. PHPA intends to distribute the information as widely as possible through the national media, in schools and at the Army Staff College in Jakarta (Wilkinson, 1995). Excerpts will be used to produce leaflets and brochures for Taman Safari Indonesia and other Indonesian zoos, funded by the Australasian agencies.

Funding for 1996 is being considered by Esso Indonesia for maintenance costs of the genome resource bank and training of PKBSI staff in assisted reproductive techniques for tigers.

Crown Pacific, another significant corporate sponsor, is providing funds to establish a rescue team for the capture and transport of problem tigers from Sumatra to Taman Safari Indonesia, maintenance and medical evaluation of these animals, maintenance of the genome resource bank and development of a public awareness programme.

BENEFITS TO TIGER CONSERVATION

The Indonesian captive Sumatran tiger programme has the potential to serve as the heart of the global programme by preserving sufficient genetic diversity to provide tigers to supplement the gene pool as recommended in the IUCN/SSC CBSG Tiger GASP. The PKBSI designed the programme to ensure that only verifiable founders that are permanently identified and registered in the regional studbook are used. The programme also extends the capabilities of Indonesian zoo staff to manage their tiger programme professionally within Indonesia. The programme can serve as a model for developing other regional captive-management programmes for tigers in South-east Asia and

was used in China for the Amoy or South China tiger *Panthera tigris amoyensis* (Wang *et al.*, 1995) and in Thailand for the Indochinese or Corbett's tiger *Panthera tigris corbetti* (Tilson *et al.*, 1995).

The long-range goal of the PKBSI Sumatran tiger Master Plan, together with the *Indonesian Sumatran Tiger Conservation Strategy* (Ministry of Forestry, 1994), is to link its activities with the reinforcement or recovery of wild tiger populations, thus providing conservation options for PHPA to prevent the extinction of wild tigers in Sumatra. PHPA intends to collect information about wild tigers, their relationship with the habitat and their prey, as well as other information about life-history characteristics. They will also evaluate the attitudes and awareness of villagers living near tiger habitat and develop ways to resolve issues between tiger and human resource use. The project in Way Kambas National Park is one of the first steps in this process and once the methodology and personnel are sufficiently developed, all protected areas in Sumatra will be evaluated for their potential for maintaining viable tiger populations.

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This article is a collaborative effort made possible by the contributions of the authors and a host of supporting organizations within Indonesia, particularly the PKBSI and PHPA. The authors hold the following positions: Ronald Tilson, CBSG Tiger GASP Coordinator, AZA Tiger SSP Coordinator and Director of Sumatran Tiger Field Study; Dwiatmo Siswomartono, Director of Nature, Fauna and Flora Conservation, PHPA; Jansen Manansang, PKBSI Sumatran Tiger Co-Coordinator; Gerald Brady, AZA Sumatran Tiger SSP Coordinator; Douglas Armstrong, AZA Tiger SSP Veterinary Advisor; Kathy Traylor-Holzer, AZA Tiger SSP Population Management Advisor; Ann Byers, CBSG Reproductive Biologist; Peter Christie, ARAZPA Carnivore TAG Convenor; Atje Salfifi, PKBSI Sumatran Tiger Co-Coordinator; Ligaya Tumbelaka, PKBSI Sumatran Tiger Studbook Keeper; Sarah Christie, EEP Tiger Coordinator; Douglas Richardson, EEP Tiger Management Advisor; Suherti Reddy, Chief of Way Kambas National Park; Neil Franklin, Field

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IN SITU CONSERVATION OF THE SUMATRAN TIGER IN INDONESIA

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Introduction

One of the most endangered species of Indonesia, the Sumatran tiger (*Panthera tigris sumatrae*), is recognized as a "key species" in biodiversity conservation (BAPPENAS, 1993) and is considered critically threatened by the IUCN (Nowell and Jackson, 1996). About 400 Sumatran tigers survive in five Indonesian national parks and two game reserves, and another 100 tigers live in unprotected areas scheduled to be converted to agriculture (Santiapillai and Ramono, 1987; Tilson *et al.*, 1994). These small fragmented populations are in need of increased protection and a comprehensive management strategy to ensure their viability. The Sumatran tiger represents the last of three Indonesian subspecies that originally occurred on the islands of Sumatra, Java and Bali. Thus, the Sumatran tiger is not only a significant single component of Indonesian biodiversity but also is symbolic of the biodiversity that remains.

The Sumatran Tiger Project

There are three important issues that affect the long-term survival of tigers in Sumatra. One is to identify the distribution and status of each tiger population and the quality of their habitat. Another is to identify how secure each population is from poaching or disturbance as well as the security of the prey base and habitat. Still another is to develop a Rapid Tiger Status Assessment methodology to accomplish the above tasks and to provide a long-term monitoring system for the evaluation of protection and management policies sanctioned by the government for the long-term viability of wild tigers. It is also important to resolve conflicts between tigers and forest-edge communities living in proximity to tigers, as well as to develop a comprehensive conservation message to all citizens of Indonesia (Ministry of Forestry, 1994).

The first step in providing answers to these issues was taken in 1992 when the Indonesian Department of Forest Protection and Nature Conservation (PHPA) conducted a Population and Habitat Viability Analysis (PHVA) of the wild Sumatran tiger population with the assistance of the IUCN/SSC Conservation Breeding Specialist Group (CBSG) and the American Zoo and Aquarium Association (AZA) (Tilson *et al.*, 1994). Using field reports from PHPA staff and a preliminary Geographic Information System (GIS) database to outline spatial fragmentation and population modelling to estimate the status of tiger populations in Sumatra, PHPA was able to gain a basic understanding of the tiger's status, distribution and threats throughout Sumatra (Faust and Tilson, 1994; Seal *et al.*, 1994; Soemarna *et al.*, 1994).

In recognition of the situation, the *Indonesian Sumatran Tiger Conservation Strategy* was developed by the national conservation authority of the Republic of Indonesia, the Directorate

General of Forest Protection and Nature Conservation (PHPA) in the Ministry of Forestry (Ministry of Forestry, 1994). This document identified an initial set of priorities for conserving tigers, including frameworks for both *in situ* and *ex situ* conservation programs. To our knowledge, no other Southeast Asian tiger range country has produced such a document.

Based upon recommendations set forth in the *Indonesian Sumatran Tiger Conservation Strategy*, a long-term field study of Sumatran tigers was designed. Its objectives are to develop a cost-effective tiger monitoring system (using ground-based census counts, remote camera census, and radiotelemetry), to collect data on tiger life history characteristics vital for managing wild populations, to resolve human-tiger conflicts by partitioning forest resources in an equitable and sustainable manner, to start up community-based tiger education programs, and to train university and PHPA counterparts to become future conservation leaders in Indonesia (Tilson, 1995a; Tilson and Franklin, 1995; Bastoni, 1996; Franklin, 1996; Sriyanto, 1996).

The field component of the Sumatran Tiger Project was initiated in June 1995 in Way Kambas National Park (WKNP), a 130,000 ha lowland rain forest habitat comprised of primary forest, early and late stage secondary forests, grasslands, swamp and mangrove forest situated in southeastern Sumatra, Lampung Province. The Indonesian Institute of Sciences (LIPI) is the sponsoring agency, and the Indonesian Ministry of Forestry and Taman Safari Indonesia (CBSG-Indonesia Program), by signing an Memorandum of Understanding (MOU), are the official collaborating agencies. A base camp was established at Way Kanan in the middle of the park, field research staff were recruited, and a number of field projects are now underway. The community conservation and education component was initiated in December 1995, focusing on villages in the sub-districts (*kecamatan*) of Sukadana and Way Jepara (adjacent to WKNP).

Tiger Biology Field Study

The goal of the field research component is to provide insights into the Sumatran tiger's natural history that will lead to improved conservation management practices for wild tigers by PHPA. Since Sumatran tigers are known to occupy a wide range of habitat types in Sumatra, it is important to investigate the effect of diverse factors such as habitat characteristics, prey base, competition, distance from forest edge, and human disturbance. Techniques will be developed for the censusing and monitoring of wild tigers, including the development, in Way Kambas, of a rapid assessment methodology to be used over the whole of Sumatra.

This will be achieved by a comparative study of the current methodologies available for the censusing and monitoring of wild tigers. Infrared-activated remote cameras, passive trail monitors, and remote video cameras will be of central importance to this investigation, with the results combined with data on tiger ecology to be obtained from radio-telemetry of select tiger individuals (late 1996/early 1997). In addition, correlations will be evaluated between tiger density and the encounter frequency of tiger secondary signs, while the rapid assessment of prey-base, habitat security, and human intrusion will also be investigated. A comparison of the above techniques will have a wider significance than for tiger ecology and monitoring alone, with the development of remote camera census techniques having significant implications for wildlife monitoring in general.

Another objective is to use the developed methodologies to establish vital ecological characteristics of the Sumatran tiger. These will include details regarding the tigers' habitat preference, ranging and space use behavior, activity patterns, social system, and interactions with other species. It will incorporate a consideration of prey-base distribution and availability, prey selection patterns, and an analysis of what is needed to support a population of tigers. Where possible, more detailed reproductive information such as interbirth intervals, cub survivability, and subadult dispersal patterns will be documented.

Long-Term Monitoring of Wild Tigers

Wild tigers are extremely difficult to census because of their secretive nature and near complete avoidance of humans. In the forests of Sumatra, the census of tigers is compounded by the fact that most of the national parks and protected areas are huge, some of these areas are so remote or so inundated with water that they are practicably inaccessible. Further, some tiger populations in Sumatra have been pushed into the higher sub-montane and montane forests, where overall prey densities, and thus tiger populations, are correspondingly low and difficult to census. One promising technique, remote camera censusing, first implemented in Gunung Leuser National Park in northern Sumatra (Griffiths, 1994), is being expanded in scope and evaluated as a tool for censusing and long-term monitoring of tiger populations throughout Sumatra.

As part of the field ecology study, a 162 km² site with a perimeter of 57 km for the long-term monitoring of a core population of tigers was identified. Plans are to extend this site to cover about 210 km². This site, representative of all habitats found in Way Kambas, has been incorporated into a GIS database. A systematic census of tigers in this area is being conducted through the use of about 25 remote infrared cameras, regular censusing by staff, and identification of tiger tracks, scrapings, and hair contents of feces (for prey identification). This will allow analysis of tiger activity by habitat type. Passive infrared monitors will also be used to assess prey activity in combination with remote camera photographs.

As of June 1996, over 4,500 photographs have been cataloged, over 70 photographs of tigers have been taken, and twelve tigers have been positively identified as residents or transients living peripherally to this site. One product of this study will be an Indonesian language manual on how to use remote-camera systems for surveying, censusing and monitoring tiger populations (Bastoni, 1996). A related component is how to use the same system to assess tiger prey base compared to line transect counts, which may not be the most efficient or effective method in lowland rain forest habitat (Sriyanto, 1996).

Additional short-term census sites of about 100 km² have been identified in the park. Eventually, the entire park will be censused. These sites are being used as training ground to develop effective, yet rapid and economical, techniques to census tigers and tiger prey in different types of habitat, as well as establishing the number of tigers living in WKNP. The results of these efforts will assist in the development of a model that can be expanded for evaluating tiger populations living in key conservation areas in Sumatra by a mobile Tiger Rapid Assessment Team (see below).

Tiger Rapid Assessment Team

Rapid assessment of tiger status and prey, using methodology developed in WKNP, will be employed throughout Sumatra, particularly high priority areas designated by PHPA by a mobile tiger monitoring team. The team will assess habitat characteristics by GIS, ground-truthed by the tiger monitoring team, permitting the evaluation of potential corridors among protected areas and correlations with tiger habitat preferences. The team will also be responsible for surveying local attitudes toward tigers and other wildlife (see below) as well as disseminating conservation education literature about the need to conserve tigers and what to do with "problem" tigers (see *ex situ* tiger programs below). The results of this Sumatra-wide survey will provide vital information to PHPA that, when combined with results from the Sumatran tiger field study, will allow PHPA to update and refine their current document, the *Indonesian Sumatran Tiger Conservation Strategy* (1994).

Community Conservation Education

Another aspect that is critical to the tiger's survival in Sumatra includes an evaluation of human resource use patterns and tiger resource needs, conflict resolution when they overlap, and local attitudes and perceptions regarding conservation issues (Nyhus and Tilson, 1995). The tasks of the community-based conservation education program are to better understand human-wildlife interactions near WKNP and to strengthen local participation in education and conservation efforts in forest-edge communities surrounding the park. To date, no detailed socio-economic studies have been carried out in communities near WKNP or incorporated with tiger biology studies in Sumatra. Conflicts between tigers, other wildlife, and humans, if left unchecked, are likely to increase and endanger the remaining populations of these animals unless steps are taken to enhance public support for conservation efforts.

One of the projects underway in WKNP to establish a quantitative and qualitative database to answer these questions is to analyze demographic data and land use patterns. Primary data are being collected from village registers, government census documents, and existing studies. Data are being mapped so that models can be constructed to determine areas where future conflicts may arise. Information is also being collected from field observations and existing local agricultural and forestry data.

Another component is to evaluate local attitudes and resource use. Information that has been gathered in the focal communities includes qualitative studies using in-depth interviews and case studies (e.g., Rapid Rural Appraisal techniques, focus groups), quantitative surveys using questionnaires (e.g., household surveys, park visitors), and field observations and analysis of secondary data.

In order to better understand human-wildlife conflicts, the location, type, extent, and frequency of wildlife disturbances is being measured by visiting communities on a regular schedule, talking with affected villagers, and mapping the disturbance areas. Newspaper reports of human-wildlife conflicts will be collected to obtain a historical record of human-wildlife conflicts in this area as well as to evaluate how local news is presented relative to its accuracy, bias and interpretation.

Community meetings and field surveys have already been undertaken in ten villages in three different *kecamatan* along the southeastern perimeter of the park. From this database, a comprehensive Indonesian language survey questionnaire was developed to quantitatively evaluate current and evolving attitudes of residents in these villages. Plans to interview every household will be accomplished through the assistance of University of Lampung students. Methods to monitor and estimate the extent of human activities in the park are being developing using interviews, GPS units and passive infrared monitoring units.

Park Support and Law Enforcement

It is no secret that tiger bones in particular are a lucrative international black-market product for use in Traditional Chinese Medicine (Mills and Jackson, 1996). Fortunately, the poaching of tigers in Sumatra is not rampant (Tilson and Traylor-Holzer, 1994; Bowles and Plowden, in press), as it is in other countries like India, Vietnam, Laos and Cambodia (Mills and Jackson, 1996). Nevertheless, the temptation for poachers to ply their trade in Sumatra will always be present, and PHPA must be ever vigilant in its resistance to it. Wildlife law enforcement by PHPA needs to be strengthened (Ministry of Forestry, 1994) and one approach is described here.

In 1990 the Minnesota Zoo initiated an "Adopt-A-Park" program to provide direct assistance to conservation efforts in Ujung Kulon National Park, West Java, Indonesia. This program helps protect wild animal populations and ecosystems by providing support to park rangers and guards in the form of equipment and new or renovated guard posts (Tilson, 1991; Tilson, 1995b).

This conservation effort was expanded in 1996 to Way Kambas National Park, which became the Minnesota Zoo's second "adopted" park, in conjunction with a companion program by the Minnesota Conservation Officers Association, called Adopt-A-Warden, which provides equipment and law enforcement training to park rangers and guards in both Ujung Kulon and Way Kambas parks (Breining, 1994; Tilson, 1996). These combined programs strengthen the effectiveness of PHPA in its protection of wild tigers, their prey and their habitat.

Development of *Ex Situ* Tiger Programs in Indonesia

The precarious status of the Sumatran tiger in the wild called for immediate initiation of a captive management program for the subspecies in Indonesia (Tilson *et al.*, 1993). These programs for captive populations were developed by the Perhimpunan Kebun Binatang Se Indonesia (PKBSI)(Tilson *et al.*, 1996a). Because the Indonesian government had already designated Taman Safari Indonesia (TSI) as the Indonesian Center for the Reproduction of Endangered Wildlife, it was also designated as the official repository for wild-caught "problem" Sumatran tigers by the Directorate General of PHPA and was selected as the site for construction of a modern zoo tiger breeding facility. The development of the PKBSI Sumatran Tiger Masterplan is specifically linked to *in situ* programs described here (Manansang *et al.*, in press). The process and involvement of international regional programs and organizations in the development of the PKBSI captive management program for tigers is reviewed elsewhere in Tilson *et al.* (1996b).

One example of a collaborative project that the PKBSI has developed with PHPA is a tiger rescue team. The team's primary function is to provide capture expertise and logistical support to

remove "problem" tigers from protected areas in Sumatra rather than having them killed by villagers, police or the military. Problem tigers, as defined by PHPA, are tigers that leave officially protected forests and come into conflict with villages, usually by killing their livestock or domestic animals. Tigers that kill villagers inside protected areas are not considered problem tigers. Another linkage is the production of an educational brochure about the tiger rescue team for distribution to government and civic offices throughout Sumatra. PKBSI is also considering the potential contribution of a Genome Resource Bank to the long-term survival of wild tigers (Wildt *et al.*, 1995). Most importantly, the *ex situ* components of the PKBSI are integrated with *in situ* components, and together they comprise the *Indonesian Sumatran Tiger Conservation Strategy*. It is an outstanding achievement illustrating how government conservation agencies, in this case the Ministry of Forestry, can work hand in hand with local zoo organizations, in this case, PKBSI and Taman Safari Indonesia.

Acknowledgements

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MEMORANDUM

To: Sarah Christie, Gerry Brady, Ron Tilson
From: Steve O'Brien
Through: Jan Martenson & Clay Stephens, LGD, NCI/FCRDC
Date: December 3, 1997
Subject: Tiger subspecies testing

Following is a summary table of the recent testing results of captive tigers for their subspecies affiliation. A pedigree compiled by Jan Martenson from the ISIS information on the Sumatran animals descended from founders #8 and # 10 is also attached.

As described by Wentzel et al. at the Tiger 2000 Symposium, we have developed a database of tiger microsatellite (STR) alleles by typing 20 microsatellite STR loci on a collection of "voucher" tiger specimens: 10 Siberian/Amur, *P. tigris altaica*; 5 Sumatran, *P. t. sumatrae*; 4 Indochinese, *P. t. corbetti*; 4 Indian, *P. t. tigris*; and 4 South Chinese, *P. t. amoyensis*.

For this collection of captive tigers, Lod Scores were derived by comparing the captive specimens' composite STR genotypes to the database of allele frequencies estimated from the voucher specimens. A Lod Score is the log of the likelihood ratio for the most probable subspecies versus the second most likely subspecies. The range of values given represents a parametric correction for alleles not observed in each subspecies, but presumed to be present at frequencies of 0.15 to 0.01 in the population at large (Stephens, et al., manuscript in preparation). A Lod score of 4.0 in comparing Sumatran vs. Indian, means the animal is 10^4 (10,000) times more likely to be Sumatran than Indian.

The number of signature alleles for the named subspecies are also listed in the table. Signature alleles are those alleles which were found in only one subspecies of the original voucher specimens but not necessarily in all animals of that subspecies.

All but one of the animals on the following table present strong Lod scores in favor of their suspected subspecies affiliation, with a second-best subspecies at least $10^{3.6}$ less likely. The exception is Sumatran Studbook #674 (Pti-225). This animal affiliated most strongly with a Sumatran genotype, but with a lower range of Lod scores; affiliation with the *corbetti* subspecies came in second. This animal had no Sumatran signature alleles but had 2 signature alleles that were not Sumatran in addition to presenting a new allele at one STR locus. Clay Stephens tested the genotype of this animal against "artificial hybrids" of various combinations and found that this animal best fits a scenario of 3/4 Sumatran - 1/4 Indochinese.

ANIMAL	Studbook #	Source	Suspected subspecies	# of STR loci scored	LOD scores	# Signature alleles of named subspecies	subspecies affiliation by LOD score
Pti-175	SB-535	Indonesia	Sumatran	17	4.8-24.4	3 Sumatran	SUMATRAN
Pti-184	SB-867	Indonesia	Sumatran	17	6.5-22.7	4 Sumatran	SUMATRAN
Pti-185	SB-877	Indonesia	Sumatran	17	4.5-18.3	3 Sumatran	SUMATRAN
Pti-209	SB-569	Louisville	Sumatran from founder #8	17	3.8-15.0	1 Sumatran	SUMATRAN
Pti-206	SB-593	San Antonio	Sumatran from founder #8	17	5.9-18.3	2 Sumatran	SUMATRAN
Pti-225	SB-674	Thrigby UK	Sumatran from founder #8	16*	2.4-4.3	0 Sumatran	SUM/COR?
Pti-227	SB-547	Thrigby UK	Sumatran from founder #10 & #8	17	4.8-18.7	3 Sumatran	SUMATRAN
Pti-150	SB-542	San Diego	Sumatran from founder #10	17	6.5-22.4	3 Sumatran	SUMATRAN
Pti-093	SB-754 (sib of 758)	San Diego	Sumatran from founder #10	17	7.1-18.7	2 Sumatran	SUMATRAN
Pti-099	SB-758 (sib of 754)	San Diego	Sumatran from founder #10	17	6.6-18.3	3 Sumatran	SUMATRAN
Pti-083	SB-533	San Diego	Sumatran, dam of -95 & -96	17	5.0-22.1	2 Sumatran	SUMATRAN
Pti-095	SB-718	San Diego	Sumatran, F1 of -83 & ?	17	5.5-20.2	1 Sumatran	SUMATRAN
Pti-096	SB-719	Phoenix	Sumatran, F1 of -83 & ?	17	3.6-17.2	2 Sumatran	SUMATRAN
Pti-100	SB-527	HD Zoo	Sumatran, suspect sire of -95 & -96	17	5.1-22.2	6 Sumatran	SUMATRAN
Pti-208	SB-526	Atlanta	Sumatran, suspect sire of -95 & -96	17	5.7-22.4	3 Sumatran	SUMATRAN
Pti-207	SB-3631	Hamburg	Altaica (son of Roman in Munich)	17	4.3-17.9	3 Altaica	ALTAICA
Pti-205	SB-2456	HD Zoo	Altaica	17	4.1-20.4	5 Altaica	ALTAICA
Pti-174	SB-872 VOUCHER	Indonesia	Sumatran CONTROL	17	6.7-20.3	4 Sumatran	SUMATRAN
Pti-121	w/c VOUCHER	Russia	Altaica CONTROL	17	5.7-20.9	5 Altaica	ALTAICA

* new allele seen for STR-FCA105 with Pti-225; did not include this locus in analysis

List of Equipment Provided in Immobilization Kits

Presented to PKBSI zoos on 3 April 1997 and funded by the Save the Tiger Fund

Equipment	Bandung	Jambi	Medan	Ragunan	Semarang	Solo	Surabaya	TSI	Yogya
Blow gun		X	X		X	X	X	X	
Blow darts and supplies	X	X	X		X	X	X	X	
Epinephrine	X	X	X		X	X			
Ketamine		X	X		X	X			
Xylazine		X	X		X	X		X	
Midazolam		X	X		X	X		X	
Dopram		X	X		X	X			
Yohimbine		X	X		X	X			
Trimethoprim and sulfa		X	X		X	X			
Tattooer	X			X	X		X	X	X
Clippers							X	X	X
Ophthalmoscope/otoscope	X						X		X
Transponder reader/case	X			X			?		X
Transponders	X	X	X	X		X	X	X	X
Transponder implanter	X	X	X	X		X			X
Crate	X	X	X	X	X	X	X	X	
Pole syringe		X	X	X	X	X	X		
Stethoscope		X	X		X	X	X		
Electric thermometer		X	X		X	X	X	X	
Dental cleaning equipmt		X	X			X	X		
Endotracheal tubes					X				X
Monoject syringes		X	X		X	X			
18 gauge needles		X	X		X	X			