INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

Bogor, Indonesia
3-5 October 1991

CAPTIVE BREEDING SPECIALIST GROUP (CBSG)
SPECIES SURVIVAL COMMISSION (SSC)
IUCN -- The World Conservation Union

Photo Credit: A. Compost

TABLE OF CONTENTS

TABLE OF CONTENTS
(Page 2)

TABLE OF CONTENTS
(Page 3)

INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

SECTION 1 - ORGANIZATION AND OVERVIEW

JUL 25 1990

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50664 KUALA LUMPUR

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Kawat: CHIEFWARD

Ruj. Tuan:

Fax: 011-60-3-905-2873

Ruj. Kami: JPHL&TN:50/IP/S Jld.5(36)

Tarikh: 16 July 1990

Thomas J. Foose,
CBSG,
12101 Johnny Cake Ridge Road,
Apple Valley,
MN 55124, U.S.A.

Dear Thomas J. Foose,

In June 1989, a Population Viability Workshop for the Javan, and to a lesser extent Sumatran, Rhinoceros was conducted in Bogor. The results and recommendations of this meeting were subsequently prepared and distributed. Unfortunately, there have been some disagreements and difficulties concerning the implementation of these recommendations, particularly the details of the proposed captive propagation component of the strategy for this species. Hence, PHPA in Indonesia has suggested that another workshop be convened, under auspices of the IUCN Asian Rhino Specialist Group, to resolve these problems.

2. Beyond considering the specific concerns relative to ex situ endeavors with the Javan rhino, it seems desirable to use the opportunity provided by the workshop to develop further a realistic and holistic action plan for conservation of both species of rhino in Indonesia. Development of such a strategy might hopefully result in a coalition of organizations to implement the action plan. Toward this goal, a tentative agenda for this meeting has been formulated and is attached.

3. The Workshop will be conducted in Bogor, Indonesia from 5-7 September 1990. The exact location of the Workshop in Bogor is at the Biotrop Institute. Further information by early August. There is also the possibility of a 5 day trip to Ujung Kulon after the Workshop.

4. Since you and your organizations have been involved and/or have indicated interest in rhino conservation in Indonesia, you are cordially invited to participate. Regrettably travel support for the meeting is limited and will be available only to those who have been contacted separately by WWF or IUCN. Other participants are requested to pay their own travel expenses. Cost of accommodations in Bogor will be modest (about U.S. $25 per person per day).

5. Virtually all of you have already been apprised of this meeting and many have already indicated their interest or intention to attend. This letter serves as your formal invitation. I would appreciate if you could formally advise me if you will be able to attend this workshop. It would also be useful if you could provide a copy of your response to Mr. Sukianto Lusli (who is organizing logistics for the meeting), Effendy Sumardja and to Simon Stuart Their addresses are:

Dr. Effendy A. Sumardja,
Director of Nature Conservation,
PHPA,
Jalan Juanda 9,
Bogor, Indonesia.

Sukianto Lusli,
c/o Russell Betts,
WWF,
Jalan Tampak Siring 13,
Cipete, Jakarta Selatan,
Indonesia.

Simon Stuart,
IUCN Species Survival Commission,
Avenue du Mont-Blanc,
1196 Gland, Switzerland.

I hope to see you at the Workshop.

Sincerely,

(MOHD KHAN BIN MOMIN KHAN)
Chairman,
IUCN SSC Asian Rhino Specialist Group.

c.c. Effendy A. Sumardja
Sukianto Lusli
Simon Stuart
Russel Betts

JUN 21 1991

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Ruj. Tuan:

Ruj. Kami: JPHL&TN:50/IP/S Jld.6(20)

Tarikh: 8 May 1991

Dr. Thomas J. Foose,
CBSG,
12101 Johnny Cake Ridge Road,
Apple Valley,
MN 55124,
U.S.A.

Dear Tom,

I am happy to inform you it is now possible to reschedule the Indonesian Rhino Conservation Workshop that had to be postponed last January because of the Gulf War. The Workshop will be conducted in Bogor 3-5 October 1991. Attached is a tentative agenda which you will see is very similar to what had been proposed for last January. Very constructive preparatory discussions concerning this Workshop occurred among those of us who were able to attend the International Rhino Conference in San Diego. I believe the October Workshop will be most productive.

Most probably the venue for the workshop and accommodations for participants will be at the Safari Garden Motel near Bogor. However, arrangements are not yet finalized. Dr. Russell Betts and his staff at the WWF Indonesia Programme have once again most graciously offered to manage the local arrangements for the meeting.

Therefore, will you please respond to me with a copy to Russell Betts if you will participate in the meeting and if you will need a room reserved for you. Please provide your address, telephone, and fax numbers in your response. The copy of your response for Dr. Betts should be directed to:

Dr. Russell Betts,
WWF Indonesia Programme,
Jalan Pela 3,
Gandaraya Utara,
Jakarta Selatan,
Indonesia.

Fax: 62-21-739-5907

Dr. Betts will inform you after you confirm attendance exactly where you will be staying. Unless otherwise advised, all participants are expected to pay their own travel and living expenses. You will also be expected to travel on your own from the airport to the hotel.

I hope you will be able to participate in this important Workshop and I look forward to seeing you in October. Please don't hesitate to contact me if you have further questions.

Sincerely,

(MOHD KHAN BIN MOMIN KHAN)
Chairman,
IUCN SSC Asian Rhino Specialist Group.

c.c. Effendy Sumardja
Russell Betts
Simon Stuart
Tom Foose

rhino4(9)

WORKSHOP ON
INDONESIA RHINO CONSERVATION
BOGOR - 3-5 OCTOBER 1991

THURSDAY - 3 OCTOBER

8:00 - 8:20	WELCOME: Sutisna
8:20 - 8:40	OBJECTIVES AND OVERVIEW OF MEETING: Stuart
8:40 - 9:00	REVIEW OF ASIAN RHINO SPECIALIST GROUP ACTION PLAN FOR INDONESIA: Khan
9:00 - 9:20	DESCRIPTION OF NEW INDONESIAN RHINO FOUNDATION: Sutisna and Effendy
9:20 - 10:00	INDONESIAN RHINO CONSERVATION PLAN: Widodo, Muladi, Sukianto
10:00 - 10:30	BREAK
10:30 - 11:00	HOLISTIC STRATEGY & PRIORITIES FOR SURVIVAL OF INDONESIAN RHINOS: Schenkel
11:00 - 12:00	REVIEW OF JAVAN RHINO PVA RESULTS AND RECOMMENDATIONS: Seal, Foose, Lacy
12:00 - 12:30	ANOTHER PVA APPROACH: Prins
12:30 - 13:30	LUNCH
13:30 - 15:30	DISCUSSION OF HOLISTIC STRATEGY, PVA, AND INDONESIAN CONSERVATION PLAN: Chair: Stuart
15:30 - 15:45	BREAK
15:45 - 16:00	MINNESOTA ZOO PROGRAM IN UJUNG KULON - Tilson
16:00 - 16:30	ORGANIZATION OF GROUPS TO FORMULATE JAVAN RHINO CONSERVATION PROGRAM: Effendy
16:30 - 18:30	WORKING SESSIONS OF JAVAN RHINO GROUPS.

1 JUNE 1991

FRIDAY - 4 OCTOBER 1991

8:00 - 10:00	REPORT FROM JAVAN RHINO WORKING GROUPS AND OPEN DISCUSSION OF THE RESULTS: Chair: van Dongen
10:00 - 10:30	FORMATION OF JAVAN RHINO COMMITTEE TO SYNTHESIZE GROUP REPORTS INTO SINGLE DOCUMENT AND PLAN: Stuart
10:30 - 11:00	BREAK
11:00 - 11:30	STATUS REPORT ON SUMATRAN RHINO IN THE WILD IN INDONESIA: Widodo, Sukianto, Dudi, Erwin
11:30 - 12:00	SUMATRAN RHINO CAPTIVE BREEDING MANAGEMENT PLAN: Effendy
12:00 - 13:00	LUNCH
13:00 - 13:30	DRAFT GLOBAL STRATEGY AND HERITAGE SPECIES PROGRAM FOR SUMATRAN RHINO: Rabb & Foose.
13:30 - 14:00	DISCUSSION OF GLOBAL STRATEGY & HERITAGE SPECIES PROGRAM: Khan
14:00 - 14:30	ORGANIZATION OF WORKING GROUPS TO DISCUSS SUMATRAN RHINO CONSERVATION PROGRAM: Effendy
14:30 - 16:00	WORKING SESSIONS FOR SUMATRAN RHINO GROUPS.
16:00 - 16:30	BREAK
16:30 - 17:30	WORKING SESSIONS.
17:30 - 18:00	FORMATION OF PROGRAM COORDINATION COMMITTEE TO RECOMMEND WAYS TO INTEGRATE AND COORDINATE RHINO CONSERVATION ACTIVITIES IN INDONESIA: Rabb & van Dongen

SATURDAY - 5 OCTOBER 1991

8:00 - 9:30	REPORT FROM SUMATRAN RHINO WORKING GROUPS AND OPEN DISCUSSION OF THE RESULTS: Chair: Foose
9:30 - 10:00	FORMATION OF SUMATRAN RHINO COMMITTEE TO SYNTHESIZE GROUP REPORTS INTO SINGLE DOCUMENT AND PROGRAM: Seal
10:00 - 10:30	BREAK
10:30 - 12:00	WORKING SESSIONS.
12:00 - 13:00	LUNCH
13:00 - 14:30	REPORT FROM JAVAN RHINO COMMITTEE AND ADOPTION OF JAVAN RHINO CONSERVATION PROGRAM: Chair: Stuart
14:30 - 15:30	REPORT FROM SUMATRAN RHINO COMMITTEE AND ADOPTION OF SUMATRAN RHINO CONSERVATION PROGRAM: Chair: Khan
15:30 - 16:00	DECISION WHETHER TO RECOMMEND SUMATRAN RHINO FOR HERITAGE SPECIES: Chair: Khan
16:00 - 16:30	BREAK
16:30 - 18:00	REPORT FROM PROGRAM COORDINATION COMMITTEE AND AGREEMENT ON FUTURE INTEGRATION AND IMPLEMENTATION OF RHINO CONSERVATION ACTIVITIES IN INDONESIA: Effendy and Rabb.
18:00	CLOSE

INDONESIAN RHINO CONSERVATION
INFORMAL MEETING
SAN DIEGO CA - 8 MAY 1991

Present: *Doherty, Foose, Khan, Lacy, Lusli, MacKinnon, Miller, Mustafa, Prasetyo, Rabb, Santiapillai, Seal, Sullivan, Widodo*

An informal meeting was conducted to exchange information and ideas relative to rhino conservation in Indonesia.

In particular, the group discussed plans and preparations for the Indonesia Rhino Conservation Workshop that had been postponed last January and is now to occur 3-5 October 1991 in Bogor, Indonesia. The draft agenda for this Workshop was reviewed and revised. Major items on the agenda include a review of the PVA process for Javan rhino, the Global Heritage Species Programme proposal for Sumatran Rhino, and the Indonesian Rhino Conservation Action Plan. Also reviewed was the Briefing Book being prepared for this Workshop. Numerous recommendations and materials were submitted for addition.

Also distributed and discussed were:

- The latest draft Studbook for Sumatran Rhino including more refined analyses of the mortality that has occurred during the program.
- The second draft of the Prototype Action Plan for Sumatran Rhino as a Global Heritage Species Programme.
- Further PVA analyses using VORTEX software from R. Lacy as well as an alternative approach developed by H. Prins. Directions for additional analyses before the October Workshop were explored.

The meeting concluded with an agreement by those attending to continue dialogue in preparation for the October Workshop to maximize the productivity of that meeting.

INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

SECTION 2 - JAVAN RHINO ANALYSIS & RECOMMENDATIONS

Table 1. Population estimates of the great one-horned rhinoceros

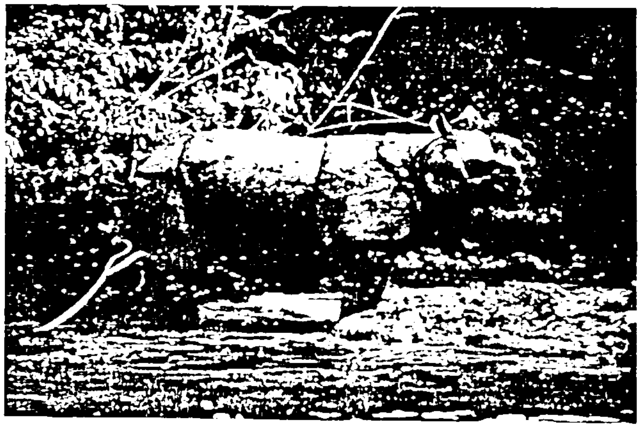
Country	Location	No of Rhino	Habitat Availability Presently (Km²)	Habitat Availability Potentially (Km²)	Protection Status	Potential Carrying Capacity
Bhutan/India	Manas	80	391	391	Wildlife Sanctuary	>100
India	Dudhwa	7	490	490	National Park	>100
India	Kaziranga	1,080	430	?500	National Park threatened by railway	1,080
India	Laokhowa	5	70	70	Wildlife Sanctuary	?
India	Orang	65	76	76	Wildlife Sanctuary	>100
India	Pobitora	40	16	16	Wildlife Sanctuary	40
India	Pockets in Assam	25	?	?	Insecure	?
India	Pockets in West Bengal	32	?	?	Insecure	?
Nepal	Royal Bardia	13	968	968	Wildlife Reserve	?400
Nepal	Royal Chitawan	375	92	?1,200	National Park	?400
Pakistan	Lal Sohanra	2	?	?	National Park	?
TOTAL		1,724				2,200 +

Table 2. Population estimates of the Javan rhinoceros

Country	Location	No of Rhino	Habitat Availability Presently (Km²)	Habitat Availability Potentially (Km²)	Protection Status	Potential Carrying Capacity
Indonesia	Ujung Kulon	50-54	761	761	National Park	?<100
Cambodia	Various	?	?	?	Not known	?
Laos	Various	?	?	?	Not known	?
Vietnam	Nam Cat Tien	Small numbers	350	?	National Park	?
Vietnam	Bugiamap	Small numbers	160	?	Reserve	?
Vietnam	Various	?	?	?	Not known	?
TOTAL		50-54 +				?

India where there remain many areas which historically had rhino populations. These areas should be protected and new populations established in them through translocations from areas where populations now exist in sufficient numbers to be unaffected by animals being taken out of them.

2.2 The Javan Rhinoceros



Javan rhinoceros (Photo: Alain Compost)

The principle surviving population of the Javan rhinoceros is located on the Ujung Kulon peninsula, which forms the westernmost extremity of the island of Java. An estimated 50 animals now live in the area. The species was once widespread throughout the Oriental Realm from Bengal eastward to include Burma, Thailand, Cambodia, Laos, Vietnam and southwards to the Malay Peninsula and the islands of Sumatra and Java. About 150 years ago the species occurred as three discrete populations. The first, belonging to the subspecies *inermis* (now almost certainly extinct) was found from Bengal to Assam and eastwards to Burma. The second subspecies *annamiticus* occurred in Vietnam, Laos, Cambodia, and the easternmost part of Thailand. The third subspecies, the nominate form, was found from Tenasserim, through the Kra Ithmus into the Peninsula and Sumatra and in the western half of Java. All these populations have disappeared, except for in Ujung Kulon and some scattered remnants surviving in Indochina. The Javan rhino has the distinction of being the rarest large mammal in the world. Population estimates are given in Table 2, and the past and present distributions are displayed in Figures 2a and 2b.

The 50 or so Javan rhinos in Ujung Kulon are in a national park and the population size is probably limited to the

Figure 2a Approximate former distribution of the Javan rhinoceros (shaded area).

effective carrying capacity of the area. One danger to these animals comes from disease, which could potentially wipe out the entire population. In 1981-1982, this threat became a reality when an unknown disease actually killed at least five animals in Ujung Kulon. In addition, any such small population of rhinos faces a permanent threat from poachers. There are no Javan rhinos in captivity.

Figure 2b Current distribuition of the Javan rhinoceros. 1: Ujung Kulon; 2: Nam Cat Tien; 3: Bugiamap. Note: the records mapped in Laos and Kampuchea refer to scattered sightings, and it is not clear whether any of these constitute substantial populations.

It is suggested that the situation facing this species be looked at very closely to see if recommendations to translocate some animals into other areas, such as Way Kambas or southern part of Bukit Barisan Selatan National Park in Sumatra should not be seriously considered. A single small population is always extremely vulnerable. It must be kept in mind that the Ujung Kulon peninsula is on the Sundaic edge volcanic line and that during the Krakatau eruption in 1883, the entire peninsula was affected by tidal waves and ash rains which destroyed much of its terrestrial life.

A second approach is that the Indonesian authorities should also consider bringing some animals into a captive breeding project to be based at least partly in Indonesia.

Better exploration of the situation in Vietnam, Laos and Cambodia also needs to take place, with the option of captive breeding again being considered. Such information might become available as fieldwork on the kouprey *Bos sauveli* conservation programme get underway.

2.3 The Sumatran Rhinoceros

The Sumatran rhinoceros was once found from the foothills of the Himalayas in Bhutan and eastern India, through Burma, Thailand, and the Malay Peninsula, and on the islands of Sumatra and Borneo. There have also been unconfirmed reports of the species in Cambodia, Laos and Vietnam. The past and present distributions are displayed in Figures 3a and 3b and population estimates are given in Table 3. In general this species has survived much better in its native habitats than the Javan rhino. This may be partly because it mainly inhabits the mountains and forests of higher elevations which were not so subject to development and logging. In contrast the Javan rhino is a species of the coastal plains and river valleys.

At present the species survives in pockets in Burma, Thailand, the Malay Peninsula, Sumatra and Borneo. Little is known of its status in Burma which holds the subspecies *lasiotus*. The nominate subspecies *sumatrensis* is now represented by animals in Thailand, Peninsula Malaysia and in Sumatra. There has been little recent news of animals in Thailand and its continuing occurrence there is now in doubt. In the Peninsula there are an estimated 100 animals surviving in several isolated pockets of which perhaps only two are in protected areas of sufficient size to guarantee long term viability. All these animals have to be closely protected.

The largest number of the subspecies *sumatrensis* now survives on the island of Sumatra and it is possible that several hundred animals still exist. However, the island is now in a phase of intense development resulting from Indonesia's transmigration programme and the habitat available to the species is being rapidly reduced. In addition the sheer size of the island, compared to the available staff for protecting the species, makes adequate protection almost impossible. Even in areas where there is a strong presence of protection staff, poaching is active. This is evidenced by the fact that in a project to capture animals for a captive breeding programme in an area where numerous wildlife staff are positioned, animals are being caught with fresh snare wounds on their legs.

The rhinos in Sumatra are too widespread and in too many pockets for all of them to be protected adequately in the ranges where they still survive. As a result, they are subject to

- an investigation into the possibilities of local people deriving economic benefit from rhino conservation in their areas (possibly through tourist revenues);

- maintenance of wildlife management and protected areas training programmes for staff at all levels.

2. Calculate the resources currently available and those additionally required to provide adequate protection for these populations.

The Indian Government should be encouraged to declare whether additional resources are needed for its rhino recovery programme. If so, these should be specified, and the necessary funds sought.

3. Assess the value to the conservation of the species of the small remnant populations of rhinos (e.g. Jaldapara), through better information on current status and cost-benefit analyses of increased protection and management.

In particular, investigations are needed of the various small populations in Assam and West Bengal, which will never be viable in themselves, to determine whether these animals might best be used as founder stock for reintroductions elsewhere.

4. Conduct biochemical and genetic studies to investigate if now disjunct populations in the Terai and the Brahmaputra Basin constitute evolutionarily significant units (ESUs) justifying preservation as separate entities.

See recommendation for Nepal.

5. Continue efforts to establish other wild populations elsewhere in India and Nepal through translocations.

Much deserved credit has been given to the Indian Government for its successful reintroduction of rhinos to Dudhwa National Park. However, with a founder stock of only seven animals, the operation cannot yet be considered complete. To avoid the problems of inbreeding, it would be advisable to move in another 30 animals. Other sites for reintroduction should also be considered.

Reintroductions should be limited to sanctuaries capable of supporting rhino populations in excess of 100 animals. A minimum of 30-40 rhinos should be used to form the foundation of new populations, and follow-up surveillance should be initiated to measure the success of such reintroductions.

6. Investigate alternatives to the proposed railway line bordering the Kaziranga National Park.

It is essential that the integrity of this outstanding area, containing the largest population of any species of rhino in the world, is not jeopardised by such a development.

7. Expand the captive population to at least 150 rhinos, mainly through propagation of rhinos already in zoos.

See recommendation for Nepal.

8. Encourage wildlife officials and the government in India to participate more fully in the activities of the IUCN/SSC Asian Rhino Specialist Group.

In this regard, the proposal from the 1986 Jakarta ARSG meeting that a future meeting be held in India should be implemented.

9. Continue measures to prevent illegally poached rhino horn from leaving India for markets in eastern Asia.

Continued instances of poaching in India suggest that the government cannot afford to ease off in its attempts to close down the illegal exports of rhino horn from the country.

3.6 Conclusion

Of the three Asian species of rhino, the great one-horned rhinoceros seems to be in the best situation at this time. However, significant threats, such as problems of habitat disturbance and poacher activity still exist. The species can be monitored with relative ease, in comparison with the other two species, because of the habitats it favours. It occurs at its highest densities in the early successional habitats, which regenerate quickly, often within 1-2 years of a major disturbance. This contrasts with the habitat requirements of the Sumatran and Javan rhinos which are more heavily dependent on primary rain forest. Thus, it does not require generations of patience to restore the great one-horned rhinoceros's habitat, but rather continued vigilance in protecting the population, and courage on the part of wildlife managers and conservationists to expand the already successful translocation programme.

4. The Lesser One-horned or Javan Rhinoceros: An Action Plan

4.1 Introduction

The only easily accessible and well known population of the Javan rhinoceros occurs in the Ujung Kulon National Park in West Java. The species has the distinction of being probably the rarest large mammal in the world. The most important threat to the species is from poaching. In Indochina, there might also be the threat of habitat destruction (it being an inhabitant of tropical lowland forest).

In Indonesia, the Javan Rhino has been legally protected since 1931. Ujung Kulon National Park was set aside for the conservation of the species. The area is managed by the local wildlife directorate, the PHPA (Perlindungan Hutan dan Pelestarian Alam), which oversees the conservation and the management of wildlife. This Directorate General comes under the Ministry of Forestry.

The situation in Vietnam, Laos and Cambodia is very unclear. There have been a number of scattered records from all three countries in recent years, but nothing to suggest that there are any concentrations of animals that could form viable populations.

4.2 Objectives

1. To preserve the remnant populations in the wild.
2. To locate and/or establish other populations in the wild.
3. To develop a captive propagation programme to reinforce this species in the wild, but in a way that minimizes the demands on the tiny wild population.
4. To continue efforts to close down the trade in rhino products.

4.3 General Recommendations

1. Conduct an intensive survey in Ujung Kulon National Park, Java, to determine more precisely the size and composition of the population surviving there. The intensive survey should be carried out by competent ecologists.
2. Determine what resources are currently available, and those that are additionally required, to provide adequate protection for the population in Ujung Kulon. This should include a consideration of human needs in the buffer-zone outside the park.
3. Investigate the status of Javan rhino in Vietnam, Laos and Cambodia. This investigation should be conducted in conjunction with the Kouprey Conservation Programme.
4. Develop as soon as possible a captive propagation programme, based on information obtained by the intensive survey of Ujung Kulon and the explorations in Indochina.
5. Formulate guidelines, and perhaps conduct a search, for a site to establish additional wild populations in South-east Asia. Animals should be made available for reintroduction from the captive breeding programme.
6. Introduce and enforce strict measures to ban the use of Javan rhino products in all countries, especially in Laos, where internal consumption is still permitted. More severe measures against poachers and traders are needed.

4.4 Indonesia (Java): Specific Recommendations

The situation of the Javan rhino is an emergency, and only a broad, integrative conservation programme is likely to save it from extinction. Because of the uncertainty of the situation in Indochina, initial efforts must be direct to the animals in Ujung Kulon National Park. With such a small population, and continuing incidences of poaching, the following actions are necessary (each recommendation below is in the same order and numbering as the General Recommendations earlier in the Chapter):

1. Conduct an intensive survey of the species in Ujung Kulon National Park.

This is an essential pre-requisite to recommending further conservation action. The survey is of such importance that it should be led by top quality ecologist should concentrate on the size, composition and habitat preferences of the population occurring there, and should assess the principal threats to its continued survival. Standardised censuses should be carried out annually thereafter.

Javan rhinoceros (Photo: Alain Compost)

2. Determine what resources are currently available, and those that are additionally required, to provide adequate protection in Ujung Kulon.

This should lead to a comprehensive management plan for the entire area, which should include:

- strong anti-poaching measures;
- training of PHPA staff at all levels in wildlife and protected area management;
- an extensive public education programme among local people as to the unique importance of Ujung Kulon National Park and its rhinos;
- initiation of appropriate forms of development in a buffer-zone outside the park to enable local people to derive tangible economic benefits from the park.

3. Recommendation number three is not relevant to Indonesia.

4. Develop as soon as possible a captive propagation programme.

This is is essential, since the population in Ujung Kulon is not large enough, and probably never could be, to be viable in genetic and demographic terms. The only possibility to expand the population rapidly, and thereby arrest the continuing loss of genetic variation, is to develop a captive breeding programme. This should be done as a collaboration between the Indonesian Government and North American and European zoos. The programme will need to consider where the initial breeding centre should be located and how to expand the population as quickly as possible, and yet minimise demands on the wild population.

5. Formulate guidelines, and perhaps conduct a search, for a site in which to establish additional wild populations in South-east Asia.

This is a very high priority, which should follow on from the captive breeding programme. The area to be selected should be within the historical range of the species, with suitable habitat for the animals to survive at a relatively high density, of sufficient size to support a viable population, and with good security against poachers.

6. **Enforce strict measures to prohibit the use of Javan rhino products in Indonesia.**

This is to include the application of the strongest possible penalties against poachers and traders.

4.5 Vietnam, Laos and Cambodia: Specific Recommendations

Because of the very uncertain situation of this species in Indochina, only recommendations number three and six apply at this stage. Surveys should be coupled with the Kouprey Conservation Programme, and probably will not require additional funding. A survey in Nam Cat-tien National Park and Bugiamap Reserve in Vietnam is of particular importance. An internal ban on the use and marketing of rhinoceros products in Laos is also needed.

4.6 Conclusion

A recovery programme for the Javan rhinoceros is one of the most pressing species conservation priorities in the world. The loss of this species would be a supreme act of negligence on behalf of the conservation community.

5. The Asian Two-horned or Sumatran Rhinoceros: An Action Plan

5.1 Introduction

The Sumatran rhinoceros is a species of rainforest in hilly and mountainous areas. It is much more widely scattered, often in tiny inviable populations, than the other two species. As a result, it is more difficult to make decisions as to the most appropriate priorities for its conservation, especially since a number of national and state governments are involved. Although not yet as critically threatened as the Javan rhinoceros, this species is probably experiencing the most serious level of poaching for its horn of all the Asian rhinos. In some areas it is also threatened by habitat destruction. In view of these complexities, it has been felt best to handle the specific recommendations for each country in a slightly different way from the previous two species.

Development of captive populations in North America and England, as well as in the countries of origin, is considered important for several reasons:

1. There are significant risks (e.g. disease epidemics, natural disasters, etc) of having all the rhinos in only a few places.

Sumatran rhinoceros
(Photo: Department of Wildlife and National Parks, Malaysia)

To ensure maximum security, the population should be distributed as widely as possible.

2. For long-term viability, the captive population needs to be larger than existing South-east Asian facilities can reasonably accommodate.

3. There are appreciable resources and expertise in North American and British zoos that can be utilized to expedite the expansion of the captive population.

However, it should also be noted that for a variety of reasons the mortality among animals that have been transported beyond the borders of their countries is extremely high. Of the five animals moved so far three have died, a 60 percent mortality. This does not compare well with the overall mortality of the capture programme in which five animals have died out of 17 captures (29.4 percent). In fact the mortality falls to 15.4 percent (two mortalities out of 13 animals) if the mortalities of exported animals are excluded from the calculations.

Therefore, it is essential that certain conditions be satisfied when animals are to be transported to foreign destinations. These are:

1. There must be accurate and as complete information on the animal/animals as possible. This should include complete veterinary records.

2. The animals should not only be in excellent health but should be free from any significant physical deformities or injuries. As far as possible the animals should be in perfect condition.

3. The animals should be physically prepared for their new homes and should be preconditioned, at least partially, to the new diet regime before they are moved.

THE CONSERVATION OF RHINOS IN INDONESIA

IUCN/PHPA

Points of Agreement

GENERAL POINTS

1. The recovery of the populations of the Javan and Sumatran rhinoceroses to levels that would ensure their long-term survival is among the highest conservation priorities in Indonesia.

2. The responsibility for saving these species and their natural environments rests with the authorities and people of Indonesia.
However, the survival of these species are of importance and interest to the whole world and hence the international community should also contribute to the conservation of these species and their habitats.

JAVAN RHINOCEROS

3. The long-term goal is to save the Javan rhino in its former and present natural habitat. This will entail the establishment of a total population of at least 2000 rhinos distributed over 10 to 20 viable populations (i.e., populations of 100 animals or more) in secure areas throughout the former range of the species (including in countries outside Indonesia). This means identifying and adequately protecting natural forests in advance of reintroductions or translocations.

4. To achieve this goal, the first priority is to provide strict protection for the surviving population in Ujung Kulon National Park, ensuring that the level of poaching is zero. Methods for bringing this about are given in Appendix X.

5. Another priority is to identify and protect potential forest sites for re-establishment of rhino populations in the future.

6. However, the population of rhinos in Ujung Kulon is not, and never can be, of sufficient size to secure the species for the long-term. It is too small for long term viability in ecological, demographic, and genetic terms. Plainly, it is vulnerable to catastrophic events or circumstances. In short, the Javan rhino is now in the process of becoming extinct and will be extinct unless we take action now.

7. It is likely that the population in Ujung Kulon is at, or is approaching, carrying capacity of the environment, and cannot be expected to increase much further.

8. The response to this dilemma by removal of animals from Ujung Kulon to establish other populations can be supported by decision analysis, and population viability analysis indicates the level of removal that can be sustained without impairing the survival of the Ujung Kulon population. As a matter of high priority, it is therefore recommended that two additional

populations be set up as soon as feasible by removing animals from Ujung Kulon. The biological and management arguments and the capture protocol are given below.

9. The greatest concern for the genetic and demographic survival of the species is to rapidly increase its numbers and to establish populations in other locations. This means a closely managed situation is preferable initially, and therefore a captive breeding program is indicated. One of the initial captive propagation sites could be situated in or adjacent to a prime translocation or reintroduction site in Sumatra. The other captive propagation site should be located near Bogor based upon a detailed site analysis.

10. Before removals from Ujong Kulon can take place, it is essential that the receiving sites be adequately prepared, including all the necessary aspects of protection.

11. Identification, preparation, and protection of additional proposed relocation and reintroduction sites should be started as soon as possible, unless such sites be lost, thereby jeopardizing the long-term goals of the recovery programme.

12. Based on a risk analysis of advantages and disadvantages of potential sites, the first removals and transfers to the receiving sites should take place in 1990. Removals and transfers should continue in 1990 and 1991 until the required numbers of animals are obtained. Procedures for capture and captive management are given below.

13. Additional captive breeding facilities should be considered in relation to the conservation needs of the species as the captive bred population expands.

14. All aspects of the conservation work on the Javan rhino should be accompanied by appropriate monitoring and research, including monitoring of the Ujung Kulon, captive, translocated, and reintroduced populations. Guidelines for research are given below.

15. Similarly, all conservation projects on the Javan rhino should include a training component, including captive breeding projects. Guidelines for training are given below.

SUMATRAN RHINOCEROS

16. The long-term goal for the species in Indonesia is to secure viable populations in the wild amounting to at least 1000 animals in Sumatra and 300-500 animals in Kalimantan.

17. The top priority is to enforce strict protection and anti-poaching measures in Kerinci-Seblat, Gunung Leuser and Barisan-Selatan National Parks. The guidelines given below apply to the Sumatran rhino as well, except that specific anti-poaching units are needed in addition to normal reserve guards.

18. Surveys are needed to locate additional viable populations for protection in Sumatra (perhaps in northern Aceh and Gunung Patah), and in Kalimantan (perhaps along the border with Sarawak).

19. The existing capture programme for doomed animals for captive breeding should be continued until such time as sufficient founder animals are available for zoos, both in Indonesia and in the United States and the U.K.

20. The captive breeding programmes should not only secure the total population adequately for long term survival, but also to provide animals for selective reintroductions, and a programme for such reintroductions should be developed as appropriate.

21. The Sumatran Rhinoceros conservation programme has similar training, monitoring, and research needs to the Javan Rhinoceros Programme. Training, in particular, should be an integral part of each project.

22. If no viable population can be found in Kalimantan, a long-term activity would be to enter into an agreement with Malaysia to seek animals from the Sabah captive breeding programme.

CLOSING POINTS

23. A Rhinoceros Conservation Unit should be established within the PHPA to have responsibility for all operational aspects of rhino management in Indonesia.

24. The effectiveness of protection measures for important rhinoceros populations is closely related to the attitude of the local people to the local people in the protected areas. Similarly, education and awareness programmes are needed in all parts of Indonesia, emphasizing the country's importance and responsibility for both species of rhino.

25. Appropriate rural development projects in the buffer zones around the reserves is an important means of avoiding and resolving conflicts over resource use.

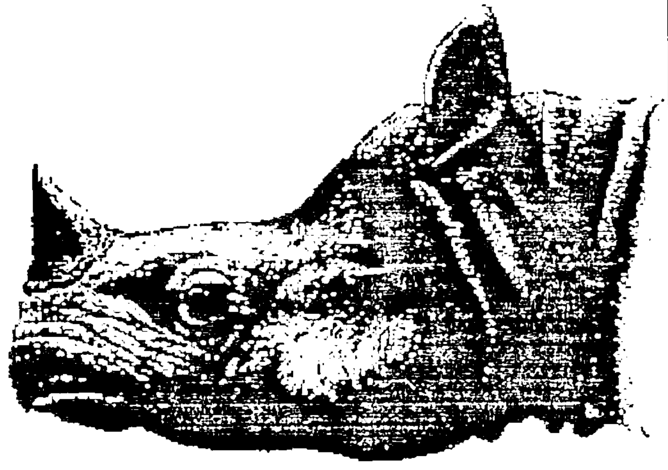
26. Continued vigilance is needed to eliminate the illegal trade in rhinoceros products, and to bring offenders to justice. Increases of penalties and other appropriate actions are recommended to enhance the enforcement of the laws dealing with these crimes.

27. International cooperation on rhinoceros conservation with other Asian countries should be pursued, with a view to sharing information and uncovering illegal trading routes.

28. An international awareness and fund-raising programme on the conservation needs of Indonesia's rhinos should be launched as soon as possible.

Javan Rhinoceros

Rhinoceros sondaicus



Population Viability Analysis

5-7 June, 1989
IUCN/SSC
Captive Breeding Specialist Group

CBSG

Captive Breeding Specialist Group

Species Survival Commission
International Union for the Conservation of Nature and Natural Resources

U. S. Seal, CBSG Chairman

Date: 12 January 1990

Subject: Javan Rhinoceros PVA Report

From: U. S. Seal, CBSG

To: Readers of the Report

1. Enclosed is a copy of the report on a Population Viability Analysis for Javan Rhino that was initiated at the Workshop on Indonesian Rhino Conservation sponsored by PHPA and IUCN in Bogor 5-7 June 1989.

2. This document contains the PVA analyses, documentation on the concepts guiding the analyses, and information on the analytical and simulation models used including their assumptions. Disk copies of the software used are available for MS-DOS machines (IBM PC compatibles). A hard disk is required and a mathematics coprocessor is desirable for some of the models.

3. The document also includes an appendix with a copy of the minutes of Bogor the meeting and a consensus report by the participants in the workshop. Various other protocols are also included.

4. Comparison of the Bogor workshop consensus report and the recommendations in the PVA report will reveal a number of differences. These differences reflect a substantial number of additional analyses that were done after completion of the workshop and that were not reviewed and discussed by all of the participants in the workshop. These recommendations and suggested scenarios therefore do not reflect a consensus by workshop participants. Instead they are based upon the results and options suggested by the additional analyses and our interpretation of these results.

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5. The basic observations of the workshop participants that are fundamental were:

   a. that the rhino population in Ujung Kulon may be near carrying capacity,
   b. that the Ujung Kulon rhinos constitute a single isolated population,
   c. that this population is gradually losing genetic diversity, and
   d. that this population is at risk of extinction from environmental events (with disease perhaps the most likely threat).

   These observations led to the consensus recommendation that a captive population (divided into 2 or 3 separate units) needs to be established, and that new reserves for additional wild populations need to established.

6. If it is decided to implement these basic recommendations, it will be desirable to discuss the various options and in depth in additional meetings. In particular it is very clear that establishment of a captive population and an additional reserve is of high priority. In our experience with other species which have been the subject of this approach the first decision to undertake a new program has been most difficult. It has always been necessary to discuss in depth the details and the methods for implementation of the program to assure the maximum benefit to the species at the least risk. The same approach will undoubtedly be desirable for the Javan Rhinoceros.

U. S. Seal

1991 VORTEX SIMULATIONS OF JAVAN RHINO POPULATIONS IN UJUNG KULON

T.J. Foose, R.C. Lacy, U.S. Seal
15 September 1991

INTRODUCTION

PVA analyses use computer models which incorporate demographic and genetic characteristics of the population(s) and conditions in the environment to simulate probable fates (especially extinction) of the population(s) under these circumstances.

Since the 1989 Workshop and Report on population viability assessment of the Javan Rhino in Indonesia, the computer simulation models have evolved and improved. A density dependence model, as described in the VORTEX documentation, is now incorporated into the VORTEX software. This permits the model to decrease reproduction as the population approaches carrying capacity or to increase reproduction as the population is reduced below carrying capacity. Hence, the model now permits the population to "recover" more realistically from declines below carrying capacity. The state of the art is described in the VORTEX section of this Briefing Book.

Using the improved models, a number of the population viability analyses are repeated here as a basis for further analysis at this 1991 Workshop. The results are presented in the next 6 tables (**Tables 1-6**) which attempt to develop the scenario of small population problems and risks in what hopefully is a logical sequence.

Each case investigated is represented by a row in the tables. A case is defined by the conditions represented by the columns of the table. Blocks of rows defined by the double lines above and below represent cases subjected to similar sets of conditions.

The simulations for each case are repeated through 1000 runs, i.e. 1000 populations are subjected to the conditions of this case.

All populations are simulated for 200 years with results reported at the end of both 100 and 200 years.

The sequence of cases are:

(1) Basic scenarios are established by assigning demographic parameters for each case. "**POPULATION PARAMETERS** column". Important demographic variables include: the carrying capacity K; the pattern of survivorship L_x. (**Table** 7); the pattern of fertility or reproduction M_x.

After basic scenarios are constructed, a number of the problems that can afflict small populations are added.

(2) First, the effects of catastrophes are explored (**CATASTROPHE** columns).

(3) Then, the effects of inbreeding are investigated. "**INBRD**" column

(4) Lastly, the effects of removing rhino from the population are examined (**REMOVALS**" column).

All simulations are investigated at 3 levels of carrying capacity (K): 100, 70, 50.

The results of the population simulations are reported in terms of:

P(E):	Probability of extinction, i.e. the number of populations out of 1000 that became extinct in the simulations.
T_E:	The mean time to extinction for those populations that did not survive. The result is reported as the mean $\pm$the standard deviation to provide a view of the range of extinction times.
POP.:	The mean final size for those populations that survive, again presented as a mean $\pm$ the standard deviation.
H_E:	The expected fraction remaining in the surviving populations of the original heterozygosity (genetic diversity).

BASIC SCENARIOS - (Table 1)

Basic population parameters are derived from 3 sources:

(1) Demographic data on *Rhinoceros unicornis* in the wild in Nepal (Dinerstein & Price 1991, included in this Briefing Book)

(2) Demographic analysis of the captive population of *Rhinoceros unicornis* in captivity in North America. (SSP 1988, included in this Briefing Book)

(3) Limited data demography of *Rhinoceros sondaicus* in Ujung Kulon (Amman 1982, included in this Briefing Book)

Survivorship and mortality schedules are selected to produce an age structure approximating these three reference populations.

In formulating the basic parameters, there is an attempt to replicate the population structure and dynamics reported in these populations, e.g. the 7% annual growth rate (λ) observed in both the Nepal and Ujung Kulon populations during periods of maximal increase or the 4-5% growth rate more recently prevailing in the Nepal population. These two rates of growth are achieved by varying the average level of reproduction.

Level 1 (7% growth rate):	On the average, 33% of the females in the population produce a calf in a given year. This pattern is equivalent in the demographic models to each female producing a calf every 3 years.
Level 2 (5% growth rate):	On the average, 25% of the females in the population produce a calf in a given year. This pattern is equivalent in the demographic models to each female in the population producing a calf every 4 years.

Incorporating density dependence permits the model population to emulate these rates of growth when density is lower and still achieve zero population growth near carrying capacity. The pattern of density dependent change in reproduction used are presented in **Table 8**. These patterns also cause the interbirth intervals to increase near carrying capacity consistent with what has been suggested for the Javan rhino in Ujung Kulon.

The newer models also produce more reasonable estimates of generation time (G) than was the case in 1989, i.e. the G's are similar to what is calculated for *Rhinoceros unicornis* populations in Nepal and in North American zoos.

Results:

At both levels of reproduction, the populations maintain their sizes near carrying capacity and their heterozygosity at high levels over the 200 year period.

EFFECTS OF CATASTROPHES (Table 2)

Catastrophes can increase mortality and fertility below the level that occurs because of normal events in the population. Two types and severities of catastrophes suggested by the recent history of the Ujung Kulon population are investigated:

Type I: A "disease" catastrophe (suggested by the 1982 death event) occurring on the average once every 10 years (.1 frequency (**FRQ**) of occurrence). It is assumed here that the effect of the catastrophe will be to increase mortality (although VORTEX also permits decrease in fertility). Two levels of severity (**SRVT**) in mortality are imposed.

Severity 1: .1 (10%) increase in mortality which is equivalent to a survivorship of .9 (90%) of what it is without the catastrophe. This level of mortality is suggested by the 5 carcasses actually discovered in the 1982 death event when the total population was estimated at about 50.

Severity 2: .2 (20%) increase in mortality which is equivalent to a survivorship of .8 (80%) of what it is without the catastrophe. This level is suggested by the speculations that not all carcasses were discovered in 1982 (Van Strien report).

Type II: A "poaching" catastrophe. Poaching can be modelled as either a stochastic or a deterministic event. It is here modelled as a stochastic event, as a continuing catastrophe. The frequency is .5 (50%) which is equivalent to an event occurring every other year. The severity is .02 (2%) removal of the existing population which in a population of about 50-60 animals represents a loss of 1 individual. This level is consistent with estimates at the last Workshop.

The catastrophes are investigated with respect to both levels of reproduction (.33 and .25).

Results: **Four sets of cases:**

At the higher level of reproduction (.33) and the lesser severity of the "disease" Catastrophe I (.9), all populations maintain their sizes near carrying capacity. By year 200, genetic diversity is at high levels for populations with K = 100; lower for K = 70; and for K = 50, almost 25% of the original genetic diversity is lost. (As is true in all "50 K" cases in this Table.)

At the higher level of reproduction (.33) and the greater severity of Catastrophe I (.8), mean final population sizes are slightly lower and standard deviations around mean (instability) are higher. Moreover, the cases with carrying capacity of 50 are already manifesting some extinctions.

At the lower level of reproduction (.25) and the lesser severity of Catastrophe I (.9), mean final populations are again lower than in the basic scenarios and the populations with carrying capacity of 50 exhibit problems.

At the lower level of reproduction (.25) and the greater severity of Catastrophe I (.8), populations at all 3 carrying capacity levels have lower final population sizes and are experiencing extinctions. The smaller the carrying capacity, the greater the extinctions. Expected heterozygosity is appreciably reduced by year 200 in the populations with carrying capacities 70 and 50.

EFFECTS OF INBREEDING (Tables 3 & 4)

Inbreeding can reduce ("depress") the survival and fertility (fitness) of a small population. Inbreeding is incorporated using a heterosis model where level is measured by the number of lethal equivalents per diploid genome. The lethal equivalents are assumed to reduce fitness by increasing juvenile mortality. There is a simplistic and approximate way of appreciating what lethal equivalents are. A 10% loss of heterozygosity is equivalent to a 10% decline in fitness (as measured by increased juvenile mortality) which represents 1 lethal equivalent; 20% loss of heterozygosity = 20% decline in fitness = 2 lethal equivalents. For a fuller explanation the reader is referred to the VORTEX program as well as Ralls et. al (1988), both of which are provided in this Briefing Book.

Two levels of inbreeding are investigated:

Level 1: 3.5 lethal equivalents per diploid genome which is a value between the mean and the median for a wide range of mammals investigated by Ralls et al. (copy of paper provided in Section of this Briefing Book)

Level 2: 7 recessive lethals which represents a high value of the range reported by Ralls et al., e.g. approximates the value discovered for Eld's deer.

Inbreeding is investigated at two levels of severity of the "disease" Catastrophe I.

Severity 1: The 10% increase in mortality (i.e. the .9 survivorship value). **Table 3 - INBREEDING I.**

Severity 2: The 20% increase in mortality (i.e. the .8 survivorship value). **Table 4 - INBREEDING II.**

The "poaching" Catastrophe II is applied in all cases.

Results: Eight sets of cases.

INBREEDING I: (Lesser severity of Catastrophe I) 4 sets of cases.

At higher levels of reproduction (.33) and lower levels of inbreeding (3.5), there is some further reduction in final population sizes and genetic diversity over the "Effects of Catastrophe" cases.

At lower levels of reproduction (.25) and lower levels of inbreeding (3.5), the final populations and genetic diversity are reduced even more and for populations with carrying capacity 50, extinctions are occurring and appreciable decline in mean size occurs from Year 100 to Year 200. This latter trend is evident even for populations with carrying capacity 70.

At higher levels of reproduction (.33) but higher levels of inbreeding (7), declines of final population and expected heterozygosity are greater than at lower levels of inbreeding. Populations at all levels of carrying capacity have population sizes appreciably lower at Year 200 than at Year 100.

At lower levels of reproduction (.25) and higher levels of inbreeding (7), problems are evident for populations at all 3 levels of carrying capacity, but for K = 70 and especially K = 50, the populations clearly seem to be in an "extinction vortex".

INBREEDING II: (Greater severity of Catastrophe I) 4 sets of cases.

Populations at all levels of reproduction and degree of inbreeding are exhibiting extinction problems. Problems are least in the first set of cases (reproduction .33 and inbreeding 3.5) in Table 4. The problems increase for the 3rd set of cases (reproduction .33 and inbreeding 7) in Table 4. The problems are greatest and very severe in the two sets of cases with lower reproductive potential (.25) at either level of inbreeding but with the worse with inbreeding at 7. Populations at all levels of carrying capacity are clearly in "extinction vortices".

In general there seems to be a synergism between catastrophes and inbreeding that produce such "extinction vortices". This synergism is plausible. When catastrophes reduce the populations to low size, they experience genetic bottlenecks which increases inbreeding and can further reduce fitness and decrease the size of the population even more.

EFFECTS OF REMOVALS (Tables 5 & 6)

For purposes of this preliminary analyses, 12 adult rhino (4 males and 8 females) are removed from Ujung Kulon to establish a second population.

Animals are removed using the previous worst case scenario for catastrophes, i.e. EFFECTS OF INBREEDING II. A worst case scenario is initially investigated on the premise that the most secure approach for conservation is a strategy that will minimize regrets.

Two removal schedules are explored:

(1) removing all the animals at once in a single year (**Removal I**):
(2) removing 3 animals per year (1 male and 2 females) over 4 years (**Removal II**)

Results:

Results indicate that there is no significant effect on the population of removing this number of adult animals. Moreover, there is no significant difference between removing all the animals in one year or over 4 years. These results are consistent with the analyses conducted to produce the 1989 Javan Rhino PVA report. Obviously, other scenarios in terms of both numbers of animals removed and period over the removals occur can be explored.

CONCLUDING COMMENTS

One conclusion that emerges from these analyses appears to be the particular vulnerability of rhino populations with carrying capacity of 50 (and lower). Risks of extinction are appreciable to significant in many of the "50 K" cases. Moreover, loss of genetic diversity (heterozygosity) is significant (< 85%) by 200 years in all "50 K" cases investigated.

Many other analyses could and should be conducted. For example, it is possible also to simulate competition, e.g. from Banteng, in the models. Very importantly, it is possible to simulate a metapopulation situation, i.e. what are the expected outcomes if there are 2 populations (Ujung Kulon and a second population, wild or captive). These simulations can be performed at the Workshop.

VORTEX -- simulation of genetic and demographic stochasticity

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Fri Aug 30 16:35:20 1991

1 population(s) simulated for 200 years, 1000 runs

HETEROSIS model of inbreeding depression
with 3.50 lethal equivalents per diploid genome
First age of reproduction for females: 6 for males: 6
Age of senescence (death): 35
Sex ratio at birth (proportion males): 0.5000

Population 1:

Reproduction is assumed to be density dependent, according to:
Percent breeding = 24.79020980
+ 0.03799530 N
+ 0.00244760 NN
+ -0.00016320 NNN
+ 0.00000000 NNNN
EV in reproduction (SD around the first term in the above Eq.) = 6.25

Of those females producing litters, in an average year ...
100.00 percent of adult females produce litters of size 1

11.00 (EV = 5.50 SD) percent mortality of females between ages 0 and 1
0.50 (EV = 0.25 SD) percent mortality of females between ages 1 and 2
0.50 (EV = 0.25 SD) percent mortality of females between ages 2 and 3
0.50 (EV = 0.25 SD) percent mortality of females between ages 3 and 4
0.50 (EV = 0.25 SD) percent mortality of females between ages 4 and 5
0.50 (EV = 0.25 SD) percent mortality of females between ages 5 and 6
2.50 (EV = 1.25 SD) percent annual mortality of adult females (6 <= age <= 35)
27.00 (EV = 13.39 SD) percent mortality of males between ages 0 and 1
1.00 (EV = 0.50 SD) percent mortality of males between ages 1 and 2
1.00 (EV = 0.50 SD) percent mortality of males between ages 2 and 3
1.00 (EV = 0.50 SD) percent mortality of males between ages 3 and 4
1.00 (EV = 0.50 SD) percent mortality of males between ages 4 and 5
1.00 (EV = 0.50 SD) percent mortality of males between ages 5 and 6
2.50 (EV = 1.25 SD) percent annual mortality of adult males (6 <= age <= 35)
EVs may have been adjusted to closest values possible for binomial distribution.
EV in mortality will be correlated among age-sex classes
but independent from EV in reproduction.

Frequency of type 1 catastrophes: 10.000 percent
with 1.000 multiplicative effect on reproduction
and 0.800 multiplicative effect on survival

Frequency of type 2 catastrophes: 100.000 percent
with 1.000 multiplicative effect on reproduction
and 0.980 multiplicative effect on survival

Polygynous mating; 60.00 percent of adult males in the breeding pool.

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

Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35		Total	
1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	0	1	0	1
0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0		24 Males	
3	2	2	2	1	2	2	1	2	1	1	1	1	1	1	1	0	1	1
0	1	0	1	0	1	0	0	1	0	0	1	0	0	0	1		32 Females	

Carrying capacity = 50 (EV = 2.50 SD)

Animals harvested from population 1, year 1 to year 4 at 1 year intervals:
2 female adults (6 <= age <= 35)
1 male adults (6 <= age <= 35)

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

r = 0.009 lambda = 1.009 R0 = 1.142
Generation time for: females = 15.61 males = 15.61

Stable age distribution:

Age class	females	males
0	0.043	0.043
1	0.036	0.030
2	0.034	0.028
3	0.032	0.026
4	0.031	0.025
5	0.029	0.023
6	0.028	0.022
7	0.026	0.021
8	0.024	0.019
9	0.022	0.018
10	0.021	0.016
11	0.019	0.015
12	0.018	0.014
13	0.016	0.013
14	0.015	0.012
15	0.014	0.011
16	0.013	0.011
17	0.012	0.010
18	0.011	0.009
19	0.011	0.008
20	0.010	0.008
21	0.009	0.007
22	0.008	0.007
23	0.008	0.006
24	0.007	0.006
25	0.007	0.005
26	0.006	0.005
27	0.006	0.005
28	0.005	0.004
29	0.005	0.004
30	0.005	0.004
31	0.004	0.003
32	0.004	0.003
33	0.004	0.003
34	0.003	0.003
35	0.003	0.003

Ratio of adult (>= 6) males to adult (>= 6) females: 0.800

Population1

Year 25
N[Extinct] = 0, P[E] = 0.000
N[Surviving] = 1000, P[S] = 1.000
Population size = 32.25 (0.31 SE, 9.67 SD)
Expected heterozygosity = 0.945 (0.001 SE, 0.020 SD)
Observed heterozygosity = 0.991 (0.001 SE, 0.018 SD)
Number of extant alleles = 27.60 (0.23 SE, 7.22 SD)

Year 50
N[Extinct] = 27, P[E] = 0.027
N[Surviving] = 973, P[S] = 0.973
Population size = 27.33 (0.37 SE, 11.51 SD)
Expected heterozygosity = 0.890 (0.002 SE, 0.049 SD)
Observed heterozygosity = 0.954 (0.002 SE, 0.052 SD)
Number of extant alleles = 15.24 (0.15 SE, 4.79 SD)

Year 75
N[Extinct] = 86, P[E] = 0.086
N[Surviving] = 914, P[S] = 0.914
Population size = 22.62 (0.37 SE, 11.21 SD)
Expected heterozygosity = 0.829 (0.003 SE, 0.084 SD)
Observed heterozygosity = 0.901 (0.003 SE, 0.096 SD)
Number of extant alleles = 10.06 (0.11 SE, 3.45 SD)

Year 100
N[Extinct] = 204, P[E] = 0.204
N[Surviving] = 796, P[S] = 0.796
Population size = 18.98 (0.39 SE, 10.90 SD)
Expected heterozygosity = 0.773 (0.004 SE, 0.107 SD)
Observed heterozygosity = 0.856 (0.005 SE, 0.129 SD)
Number of extant alleles = 7.46 (0.10 SE, 2.71 SD)

Year 125
N[Extinct] = 357, P[E] = 0.357
N[Surviving] = 643, P[S] = 0.643
Population size = 15.44 (0.40 SE, 10.25 SD)
Expected heterozygosity = 0.711 (0.005 SE, 0.130 SD)
Observed heterozygosity = 0.811 (0.007 SE, 0.166 SD)
Number of extant alleles = 5.78 (0.09 SE, 2.27 SD)

Year 150
N[Extinct] = 553, P[E] = 0.553
N[Surviving] = 447, P[S] = 0.447
Population size = 14.42 (0.44 SE, 9.36 SD)
Expected heterozygosity = 0.661 (0.007 SE, 0.153 SD)
Observed heterozygosity = 0.745 (0.009 SE, 0.192 SD)
Number of extant alleles = 4.90 (0.09 SE, 1.88 SD)

Year 175
N[Extinct] = 709, P[E] = 0.709
N[Surviving] = 291, P[S] = 0.291
Population size = 11.43 (0.46 SE, 7.86 SD)
Expected heterozygosity = 0.617 (0.010 SE, 0.168 SD)
Observed heterozygosity = 0.719 (0.013 SE, 0.214 SD)
Number of extant alleles = 4.17 (0.10 SE, 1.62 SD)

Year 200
N[Extinct] = 845, P[E] = 0.845
N[Surviving] = 155, P[S] = 0.155
Population size = 9.81 (0.59 SE, 7.37 SD)
Expected heterozygosity = 0.586 (0.014 SE, 0.174 SD)
Observed heterozygosity = 0.710 (0.019 SE, 0.233 SD)
Number of extant alleles = 3.75 (0.12 SE, 1.45 SD)

In 1000 simulations of 200 years of Population1:
845 went extinct and 155 survived.

This gives a probability of extinction of 0.8450 (0.0114 SE),
or a probability of success of 0.1550 (0.0114 SE).

845 simulations went extinct at least once.
Median time to first extinction was 143 years.
Of those going extinct,
mean time to first extinction was 130.73 years (1.39 SE, 40.28 SD).

No recolonizations.

Mean final population for successful cases was 9.81 (0.59 SE, 7.37 SD)

Age 1	2	3	4	5	Adults	Total	
0.17	0.18	0.17	0.23	0.23	3.52	4.50	Males
0.22	0.25	0.28	0.23	0.21	4.12	5.30	Females

During years of harvest and/or supplementation
  mean lambda was 0.9152 (0.0012 SE, 0.0753 SD)

Without harvest/supplementation, prior to carrying capacity truncation,
  mean lambda was 0.9879 (0.0003 SE, 0.1107 SD)

Note: 0 of 4000 harvests of males and 0 of 8000 harvests of females
    could not be completed because of insufficient animals.

Final expected heterozygosity was	0.5864 (0.0140 SE, 0.1740 SD)
Final observed heterozygosity was	0.7098 (0.0187 SE, 0.2331 SD)
Final number of alleles was	3.75 (0.12 SE, 1.45 SD)

****

KEY TO ABBREVIATIONS IN PVA SIMULATION TABLES

YRS = Years Over Which Simulation Extends

K = Carrying Capacity

λ = Annual Growth Rate

M_x = Average Fraction of Females Reproducing/Year

G = Generation Time

<u>CATASTROPHES</u>
I = Type I Catastrophe
II = Type II Catastrophe
FRQ = Frequency of Occurrence (Fraction of 100 yrs)
SVRT = Severity (In Terms of Fraction of Original Survival)

INBD = Level of Inbreeding (Lethal Equivalents/Genome)

<u>REMOVALS</u>
TOT# = Total Number Removed
YRS = Number of Years Over Which Removals Occur

P_E = Extinction Probability

T_E = Average Time to Extinction

POP. = Mean Size of Surviving Populations

H_E = Expected Heterozygosity in Surviving Populations

TABLE 1 - JAVAN RHINO PVA SIMULATIONS - BASICS SCENARIOS

POPULATION PARAMETERS					CATASTROPHIES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_λ	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E
100	100	1.07	.33	16	0		0		0	0	0	0		97±5	.94
200												0		97±5	.89
100	70											0		68±4	.91
200												0		68±4	.84
100	50											0		48±3	.89
200												0		48±3	.79
100	100	1.05	.25	17	0		0		0	0	0	0		95±5	.94
200												0		95±8	.89
100	70											0		66±4	.92
200												0		66±4	.85
100	50											0		47±3	.89
200												0		47±3	.80

TABLE 2 - JAVAN RHINO PVA SIMULATIONS - EFFECTS OF CATASTROPHIES

POPULATION PARAMETERS					CATASTROPHIES I		CATASTROPHIES II			REMOVALS		PROJECTIONS			
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E
100	100	1.05	.33	16	.10	.9	.50	.98	0	0	0	0		93 ± 7	.93
200												0		92 ± 7	.92
100	70											0		65 ± 5	.91
200												0		65 ± 5	.83
100	50											0		46 ± 4	.87
200												0		46 ± 5	.77
100	100	1.04	.33	15	.10	.8	.50	.98	0	0	0	0		85 ± 14	.92
200												0		85 ± 13	.86
100	70											0		60 ± 10	.89
200												0		60 ± 10	.82
100	50											.001		41 ± 8	.85
200												.007	129 ± 47	42 ± 8	.73
100	100	1.03	.25	16	.10	.9	.50	.98	0	0	0	0		86 ± 10	.92
200												0		86 ± 9	.86
100	70											0		60 ± 8	.91
200												0		60 ± 8	.82
100	50											.001		42 ± 6	.87
200												.001	66	42 ± 7	.76
100	100	1.02	.25	16	.10	.8	.50	.98	0	0	0	0		71 ± 20	.90
200												.007	141 ± 31	71 ± 20	.82
100	70											.001		50 ± 14	.88
200												.019	153 ± 33	50 ± 15	.77
100	50											.013		35 ± 11	.83
200												.072	141 ± 41	34 ± 11	.68

TABLE 3 - JAVAN RHINO PVA SIMULATIONS - EFFECTS OF INBREEDING I

POPULATION PARAMETERS					CATASTROPHES I		CATASTROPHES II			REMOVALS		PROJECTIONS			
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E
100	100	1.05	.33	16	.10	.9	.5	.98	3.5	0	0	0		91±8	.93
200												0		89±9	.88
100	70											0		63±6	.91
200												0		61±7	.83
100	50											0		44±5	.88
200												0		40±7	.77
100	100	1.03	.25	16	.10	.9	.5	.98	3.5	0	0	0		82±11	.93
200												0		77±13	.87
100	70											0		57±9	.91
200												0		50±12	.81
100	50											.003		38±8	.87
200												.034		30±11	.73
100	100	1.05	.33	16	.10	.9	.5	.98	7	0	0	0		89±8	.93
200												0		82±11	.88
100	70											0		61±7	.91
200												0		53±11	.83
100	50											0		41±7	.88
200												.02		28±11	.75
100	100	1.03	.25	16	.10	.9	.5	.98	7	0	0	0		78±13	.93
200												.002		60±18	.86
100	70											0		53±10	.91
200												.046		31±15	.79
100	50											.002		34±9	.86
200												.323		14±9	.68

TABLE 4 - JAVAN RHINO PVA SIMULATIONS - EFFECTS OF INBREEDING II

POPULATION PARAMETERS					CATASTROPHES I		CATASTROPHES II			REMOVALS		PROJECTIONS			
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E
100	100	1.04	.33	15	.10	.8	.5	.98	3.5	0	0	0		81±15	.92
200												.003	177±29	76±18	.85
100	70											.002		56±12	.89
200												.016	157±39	49±15	.79
100	50											.012		38±10	.85
200												.080	156±41	29±12	.70
100	100	1.02	.25	16	.10	.8	.5	.98	3.5	0	0	.006		62±23	.90
200												.094	156±33	46±24	.80
100	70											.012		43±16	.87
200												.211	159±30	28±16	.73
100	50											.051		27±12	.82
200												.472	150±36	16±11	.64
100	100	1.04	.33	15	.10	.8	.5	.98	7	0	0	0		77±18	.92
200												.018	174±24	60±22	.84
100	70											0		53±13	.89
200												.085	171±26	32±18	.77
100	50											.011		32±11	.85
200												.403	166±26	15±9	.66
100	100	1.02	.25	16	.10	.8	.5	.98	7	0	0	.012		54±23	.90
200												.328	162±30	26±18	.77
100	70											.022		36±16	.87
200												.550	160±29	13±10	.69
100	50											.096		22±11	.81
200												.882	145±34	8±5	.63

TABLE 5 - JAVAN RHINO PVA SIMULATIONS - EFFECTS OF REMOVALS I

POPULATION PARAMETERS					CATASTROPHES I		CATASTROPHES II			REMOVALS		PROJECTIONS			
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E
100	100	1.04	.33	15	.10	.8	.5	.98	3.5	12	1	.001		81±16	.91
200												.005	129±51	74±18	.84
100	70											.001		56±12	.89
200												.016	163±34	49±16	.79
100	50											.006		38±10	.85
200												.078	161±33	28±12	.70
100	100	1.02	.25	16	.10	.8	.5	.98	3.5	12	1	.016		60±22	.89
200												.113	151±37	44±24	.79
100	70											.037		42±16	.87
200												.228	153±40	26±16	.73
100	50											.071		27±12	.82
200												.488	145±38	16±11	.62
100	100	1.04	.33	15	.10	.8	.5	.98	7	12	1	.002		76±18	.91
200												.020	162±39	55±23	.83
100	70											.003		51±14	.89
200												.131	172±25	32±17	.76
100	50											.015		33±11	.84
200												.417	164±28	15±10	.67
100	100	1.02	.25	16	.10	.8	.5	.98	7	12	1	.035		49±23	.88
200												.403	157±35	22±17	.74
100	70											.042		34±16	.86
200												.384	155±33	14±11	.70
100	50											.097		21±11	.80
200												.895	143±34	8±6	.60

TABLE 6 - JAVAN RHINO PVA SIMULATIONS - EFFECTS OF REMOVALS II

POPULATION PARAMETERS					CATASTROPHIES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E
100	100	1.04	.33	15	.10	.8	.5	.98	3.5	12	4	0		81±16	.91
200												.001	190	75±18	.85
100	70											.003		56±12	.89
200												.019	146±40	51±14	.81
100	50											.011		38±10	.85
200												.081	151±38	29±12	.70
100	100	1.02	.25	16	.10	.8	.5	.98	3.5			.014		59±23	.89
200												.121	153±37	44±23	.78
100	70											.019		42±16	.86
200												.245	157±35	27±17	.72
100	50											.071		27±12	.81
200												.496	147±38	16±10	.62
100	100	1.04	.33	15	.10	.8	.5	.98	7			.002		76±19	.91
200												.029	169±35	57±23	.83
100	70											.004		53±13	.89
200												.111	173±28	32±17	.76
100	50											.018		32±11	.84
200												.394	163±31	14±9	.66
100	100	1.02	.25	16	.10	.8	.5	.98	7			.016		49±24	.88
200												.411	158±29	24±17	.76
100	70											.049		34±17	.85
200												.636	153±34	14±10	.69
100	50										1	.120		21±11	.81
200												.874	142±35	8±6	.60

TABLE 7

PARAMETERS FOR ALL JAVAN RHINO SIMULATIONS

Age at First Breeding = 6 Yrs

Age of Senescence = 35 Yrs

Mortality:	Male	Female
1st Yr	27.0	11.0
Sub Adult	1.0	0.5
Adult	2.5	2.5

Sex Ratio at Birth = 0.5

Initial Population Size: 24 ♂♂ / 32 ♀♀ = 56

Approximate Age Structure
PreAdult (Ages 1-6) = 33%
Adult (Age > 6) = 66%

Mating System: Polygynous

Percentage of Males in Breeding Pool = 60%

Environmental Variance:
Mortality: Standard Deviation (S.D.) = 50% of Mean
Fertility: Standard Deviation (S.D.) = 25% of Mean
Carrying Capacity (K): S.D. = 5% of Mean

Simulations = 1000

TABLE 8

DENSITY DEPENDENCE PATTERNS & POLYNOMIALS

K = 50 Maximum M_x = .25

N	M_x
0	.250
5	.250
10	.250
15	.250
20	.250
25	.250
30	.250
35	.220
40	.190
45	.160
50	.130

Proportion Breeding = $0.247902098 + 0.000379953\ N + 0.000024476\ N^2 - 0.000001632\ N^3$

K = 70 Maximum M_x = .25

N	M_x
0	.250
5	.250
10	.250
15	.250
20	.250
25	.250
30	.250
35	.250
40	.250
45	.250
50	.225
55	.200
60	.175
65	.150
70	.125

Proportion Breeding = $0.249632353 - 0.000377209\ N + 0.000044441\ N^2 - 0.000000943\ N^3$

TABLE 8 (Continued)

DENSITY DEPENDENCE PATTERNS & POLYNOMIALS

K = 100 **Maximum M_x = .25**

N	M_x
30	.250
35	.250
40	.250
45	.250
50	.250
55	.250
60	.250
65	.235
70	.220
75	.205
80	.190
85	.175
90	.160
95	.145
100	.130

Proportion Breeding = $0.247662338 + 0.000161431\ N + 0.000007418\ N^2 - 0.000000216\ N^3$

K = 50 **Maximum M_x = .33**

N	M_x
0	.330
5	.330
10	.330
15	.330
20	.330
25	.330
30	.330
35	.290
40	.250
45	.210
50	.170

Proportion Breeding = $0.327202797 + 0.000506605\ N + 0.000032634\ N^2 - 0.000002176\ N^3$

TABLE 8 (Continued)

DENSITY DEPENDENCE PATTERNS & POLYNOMIALS

K = 70 Maximum M_x = .33

N	M_x
0	.330
5	.330
10	.330
15	.330
20	.330
25	.330
30	.330
35	.330
40	.330
45	.330
50	.300
55	.270
60	.240
65	.210
70	.170

Proportion Breeding = $0.330493464 - 0.000729883\ N + 0.000066401\ N^2 - 0.000001284\ N^3$

K = 100 Maximum M_x = .33

N	M_x
30	.330
35	.330
40	.330
45	.330
50	.330
55	.330
60	.330
65	.310
70	.290
75	.270
80	.250
85	.230
90	.210
95	.190
100	.170

Proportion Breeding = $0.326883117 + 0.000215242\ N + 0.000009890\ N^2 - 0.000000288\ N^3$

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF COMPETITION

POPULATION PARAMETERS				CATASTROPHIES					HABT	REMOVALS		PROJECTIONS			
				I		II									
YRS	K	λ	M_x	FRQ	SVRT	FRQ	SVRT	INBRD	DCLN	TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF COMPETITION

POPULATION PARAMETERS				CATASTROPHES					HABT	REMOVALS		PROJECTIONS			
				I		II									
YRS	K	λ	M_x	FRQ	SVRT	FRQ	SVRT	INBRD	DCLN	TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF REMOVALS

POPULATION PARAMETERS					CATASTROPHES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF REMOVALS

POPULATION PARAMETERS					CATASTROPHIES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF INBREEDING

POPULATION PARAMETERS					CATASTROPHIES				INBRD	REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT		TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF INBREEDING

POPULATION PARAMETERS					CATASTROPHIES				INBRD	REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT		TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF CATASTROPHIES

POPULATION PARAMETERS					CATASTROPHIES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_1	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - EFFECTS OF CATASTROPHIES

POPULATION PARAMETERS					CATASTROPHIES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_s	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - BASICS SCENARIOS

POPULATION PARAMETERS					CATASTROPHES				INBRD	REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT		TOT #	YRS	P(E)	T_E	POP.	H_E

JAVAN RHINO PVA SIMULATIONS - BASICS SCENARIOS

POPULATION PARAMETERS					CATASTROPHES					REMOVALS		PROJECTIONS			
					I		II								
YRS	K	λ	M_x	G	FRQ	SVRT	FRQ	SVRT	INBRD	TOT #	YRS	P(E)	T_E	POP.	H_E

INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

SECTION 3 - JAVAN RHINO BACKGROUND MATERIAL

Current population size:

The demographic simulation begins just before breeding, i.e., breeding occurs prior to any mortality. In the basic simulations, we started the population with 56 animals distributed as 2 less than one-year calves, 10 juveniles equally distributed through the 2-6 year age classes, and 44 breeding age (7+ year) rhinos. This age and sex structure distribution is based upon those reported by Amman from footprint measurements and associations of footprints observed. In each age class, except the adults (18M and 26F) an equal sex ratio was assumed. This number (56) matches the estimate of the number of rhinos during the June 1989 census, Figure 15.

Table 2. Suggested sex and age structures of the Ujung Kulon population.

	Scenario 1		Scenario 2	
Age	Males	Females	Males	Females
1	1	1	2	2
2	1	1	2	2
3	1	1	1	2
4	1	1	1	2
5	1	1	1	2
6	1	1	1	2
Adults	18	26	12	18
Totals	24	32	20	30

The reported age distribution differs from the approximate stable age distributions obtained from life history table analysis. It is deficient in younger animals relative to reasonable combinations of fertility and mortality values reported for rhinos. This apparent discrepancy may reflect census difficulties for the youngest age class or reproduction may be declining and the population ageing. Further information on this population will require radiotelemetry studies. An alternative scenario (2) with a higher proportion of young animals was also included in the simulations.

To examine the viability of different starting populations and the effects of removals, we used 60, 45, and 30 rhinos in alternative scenarios reflecting removals of 15 and 30 animals or the population size at different times in its history.

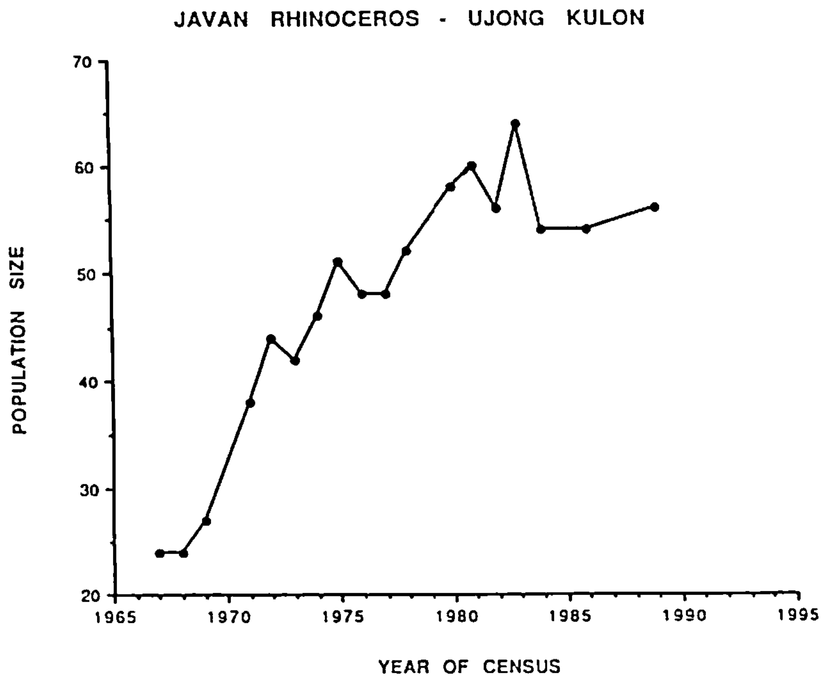

Figure 15. Census estimates for the Javan rhino population at Ujung Kulon for the years 1967 - 1989.

Carrying Capacity:

We do not know how many rhinoceroses could live in Ujung Kulon. Population numbers up to 100 have been suggested. It is also possible that the rhinoceroses are limited by the amount of preferred habitat and the expansion of banteng numbers. The present numbers of 60 rhinos may be close to the limits. We modelled carrying capacities of 70 and 100.

The approach to carrying capacity is not a simple linear function of recruitment and mortality (Figure 16). Recruitment is usually density dependent with faster rates at lower population numbers rising to a maximum and then declining (a parabolic function) to cross the death rate curve. The intersection of the two curves may be defined as the carrying capacity - K. The rising rate of recruitment at lower population sizes would reflect better nutrition and health of the females with better survival of calves and perhaps a shorter interbirth interval. This response has been observed in southern white rhinos and Indian rhinos in protected populations that had been severely depleted by harvesting activities. The declining recruitment and increasing death rate in populations near capacity can be attributed to declining nutrition and competition for limited resources.

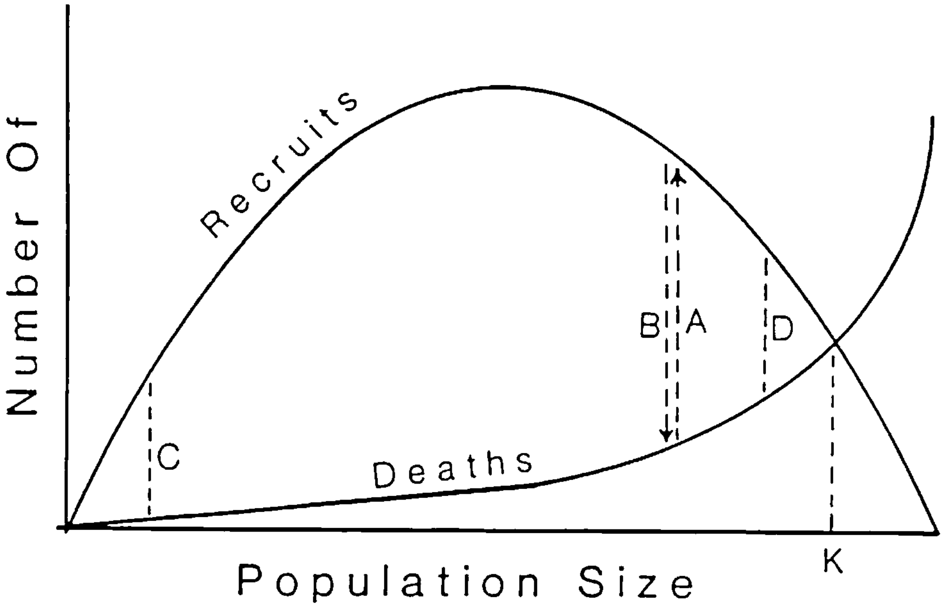

Figure 16. Simple density dependent model of population growth showing recruitment and mortality rates for a population of a species that is K-selected. (Taken from McCullough in Seal (ed.) Fertility Control of Wildlife).

The census data for the Javan rhino population at Ujung Kulon, Figure 15, indicate an increase from about 30 animals in 1970 to perhaps 55 in 1980. This amounts to a doubling time of about 12 years or an annual growth rate of 5+%. This is as high as has been reported for any rhinoceros species in the wild and captivity. There are uncertainties about the confidence limits of the census data for any given year, but the trend has been confirmed by 3 groups of investigators as has the relatively stable level of the past 10 years.

The interpretation of the Javan rhinoceros population data as indicating a population now near or at carrying capacity suggests that the growth rate is density dependent and that careful removal of animals for a captive propagation program may result in a return to the higher growth rates observed from 1970 to 1980. This would result in a return to present population numbers within 10-12 years if half of the population is removed. For this reason we modelled growth rates, after removal of animals for the captive populations, as the a low estimate (3.5%) of the rate during the period 1970-1980 and the near 0% value of the current population.

Fecundity:

Fecundity was measured as the number of wild pairs producing 0 or 1 calves each year, obtained from the census data reported over the past 10 years in Amman and in Santiapillai et al. The number of non-breeding adult rhinoceros has never been known precisely, but it has been estimated that approximately one of 8 of the adult females in the population produces a calf each year (0.12 calf per female per year). This implies an interbirth interval 8 years. This estimate was used as a lower bound for the number of breeding-age rhinos producing young each year. From these data, on average 87.5% of adults would produce no young and 12.5% would produce one calf each year. In alternative scenarios, we used fecundities of: 83.3% no calf and 16.7% one, 75% no calf and 25% one, and 67% no calf and 33% one calf. These represent interbirth intervals of 8, 6, 4, and 3 years respectively, Table 3.

Table 3. Fertilities Simulated

Birth Interval	Births 0	Births 1
8	87.5	12.5
6	83.7	16.3
4	75	25
3	67	33

It is important to remember that the calving rate is inferred from the number of young with mothers counted in the census which is based upon footprints. At low population numbers this estimate can have a significant variance. There is also a possibility of bias if the young do not move around with the female. It is also possible that young are being produced and have a high early mortality and thus are not counted. There are no direct observations of pregnant animals. Such information can be obtained (blood hormone assays and by observation) if animals are captured for removal or for radiotelemetry studies. This information is key to any analysis of possible reasons for the lack of growth in the population during the past 10 years.

Mortality:

Dead animals are rarely found except under the unusual circumstances of a mass mortality as discovered in 1982. Individual animals have not been identified and monitored over time so age and life expectancy estimates are based primarily upon footprint diameters. The only mortality data available, based on the age structure for the years 1978-1989, yield estimates of 15-30% first-year mortality, 2-6% annual mortality of subadult age classes, and 6-9% mortality of adults. We assumed that mortality of non-breeding adults is the same as that of breeding adults. Mortality of Indian rhinos is in this range, but the paucity of data and changing management make accurate estimation difficult. There are no captive data for the Javan rhino and there are too few data for captive Indian rhinos to be of much help. We simulated various combinations of the mortalities over the ranges listed, Table 4.

Table 4. Mortalities Simulated

Infant	5 - 50%
Juvenile	2 - 8%
Adult	4 - 10%

Environmental Variation:

Confirming the lack of significant annual variation in demographic parameters (over the past ten years) is the similarity observed between the variance in population numbers over the first ten years in the simulated populations when environmental variances were set to zero (V = 24) for simulations starting with 50 rhinos) and the annual variation observed in the size of the wild population over the past 10 years (V = 25). It is unlikely that birth and death rates are absolutely constant over time (even though we have no evidence that they have fluctuated over the past ten years), and for our base simulation we assumed that environmental variations in the birth rate, in death rates, and in the population carrying capacity are equal to the expected (binomial or Poisson) demographic variation. In alternative scenarios, we examined cases with no annual variation in fecundity, mortality, and carrying capacity and scenarios with environmentally imposed variation in birth and death rates and carrying capacity equal to 2, 3 and 10 times the expected demographic variation.

Catastrophes:

Biologists managing the remnant population of rhinos recognize that the risk of a catastrophe largely or wholly eliminating the species is not trivial (nor, hopefully, unavoidable). Habitat encroachment and poaching earlier in this century are believed to have reduced the rhinoceros populations. The probability and effect of a major disease epidemic is more difficult to predict, although possibly is no less likely to cause the demise of the rhinos than poaching. The recent history of the black-footed ferret makes clear the potential for disease to eliminate a small, remnant population. This small wild population of rhinos is vulnerable to a single environmental event, and the restricted habitat and increasing presence of banteng may make them more vulnerable to epidemics as well. A dispersed captive population could probably be protected from a severe storm or fluctuations in food supply, but may be vulnerable to a disease outbreak.

For the basic PVA, we assumed that the probability of a disease event, poaching or other catastrophe of similar effect is 10% annually and that such events would kill about 10% of the subadult and adult animals and would have no effect on reproduction. We also modelled scenarios with (a) no catastrophic impacts, (b) with 20% probabilities of occurrence (with the above effects), (c) with 10% probability of occurrence and 20% mortality, (d) the same as (c) with a 50% reduction in reproduction and (e) with removals of animals treated as effective one time events both in the presence and absence of unplanned losses due to disease or poaching. Also if the population is at or near carrying capacity, then removal of animals might result in an increase in recruitment rate and a return to a positive growth rate. This was modelled with shorter interbirth intervals and lower infant mortality rates.

Table 11. Javan rhinoceros - a basic scenario for the available demographic data on the Ujung Kulon population.

K = 100	T = 100 yrs	
EV = 1, 1, 1	No catastrophes	
Fertility:	75%=0	25%=1
Mortality: Inf = 25%, Juv = 2%, Ad = 7%		
P Surv = 1.000	Lambda = 1.008	
GT = 20.5	N = 91 ± 9	

Effects of Catastrophes and Removals:

A more realistic set of scenarios needs to include estimates of the probability of unpredicted removals, losses, and decreased reproduction, Table 12. We also need to consider the impact of the removal of animals for establishment of captive populations and new wild populations upon the probability of extinction and upon the demographic characteristics of the population, Figure 16. The effects of removal of about 1 animal every two years by poaching and the loss of 10% of the animals every 10 years from disease were evaluated as modest catastrophic events. The effects are additive and result in a declining population with an increased risk of extinction during the next 100 years. This effect is intensified if the carrying capacity is reduced to 75 animals which fits more closely with the level of the population during the past 10 years.

Table 12. Effects of catastrophes and removals on the population.

Scenario	P [Surv]	Lambda	N
Basic (75, 25)	1.000	1.008	91 ± 9
Catastrophe(.1,.9)	.996	.999	61 ± 23
Catastrophe(.2,.9)	.88	.988	22 ± 15
Removal (All adults)	.946	1.008	62 ± 27
+ Catas	.770	.999	46 ± 28
Removal (1/2 Ad & J)	.992	1.008	77 ± 22
+ Catas	.852	.999	40 ± 26

Two scenarios for removing animals from the population were simulated using the basic scenario developed for the population at carrying capacity and the growth scenario developed for the population based upon its growth characteristics during 1971-1980, Table 13. The effects of environmental and catastrophic variation were also examined. We evaluated the effects of removal of all adults or the removal of one-half of all age classes on projected population numbers and the probability of persistence of the population.

The populations, with carrying capacity demographic characteristics, recovered slowly in both removal scenarios and the risk of extinction was increased for the remaining wild population. However the population which suffered removal of half of all age classes had a better probability of survival and reached higher numbers by 100 years. It also was less vulnerable to the effects of catastrophe.

Table 13. Population projections: response to removals and catastrophes in a population that increases its growth rate.

	Years						P
Scenario (N)	0	20	40	60	80	100	[Surv]
Basic	50	88	91	92	91	91±9	1.000
EV 10,10,10	50	49	43	39	39	37±20	.842
CV .1, .9	50	62	65	64	63	61±23	.996
CV .2, .9	50	55	54	45	42	39±23	.938
Rem All Adults	20	27	36	46	55	62±27	.946
CV .1,.9	20	23	27	29	31	35±24	.770
Rem 1/2 A & Y	26	40	55	65	72	77±22	.992
CV .1,.9	26	30	33	35	38	40±26	.852

500 RUNS. K=100. Mortality: I=25%, J=2%, A=7%.

The populations with the demographic characteristics of a growing population, Table 13, responded more vigorously and rapidly. In order to achieve a 3.5% growth rate, the interbirth interval was set 3 years, the infant mortality at 10%, and the adult mortality at 6% with K = 75. This resulted in a rapid return within 15 years to levels near the carrying capacity, Table 13. The annual growth rate achieved was dependent upon the levels of environmental variance included and ranged from 3.3% to 1.8% over a 3-fold range in this variance. The projected final population size ranged from 67 to 46 at 100 years and the probability of extinction was near zero. These simulations suggest that if the population can be protected and if it responds as a density dependent population to a decrease in size with an increase in growth rate then it can replace the removal of half the population in less than 15 years. This corresponds to its behavior from 1971 to 1981.

Table 14. Output data for a simulation of a population responding to removal of half the population with an increase in growth rate.

```
  Polygamous breeding    First age of reproduction: 7
   67.00 percent females produce litters of size 0
   33.00 percent females produce litters of size 1
   10.00 percent mortality between ages 0 and 1
    2.00 percent mortality between ages 1 and 7
    6.00 percent annual mortality of adults (age > 7)
  Carrying capacity of 75
  Environmental stochasticity:
    Reproductive success binomial variance x  1.000
    Mortality binomial variance x  1.000
    Carrying capacity poisson variance x  1.000
  Frequency of type I catastrophes: 10.000 percent
    with  1.000 mean multiplicative effect on reproduction
     and  0.900 mean multiplicative effect on survival
  Population simulated for 100 years, 100 runs
  Initial population size:
    1 males, 1 females 1 years old
    1 males, 1 females 2 years old
    1 males, 1 females 3 years old
    1 males, 1 females 4 years old
    1 males, 1 females 5 years old
    1 males, 1 females 6 years old
    18 male, 26 female adults (age > 7)
  Population managed with supplementation/harvest through year 1 of:
    -1 males, 0 females 1 years old
    0 males, -1 females 2 years old
    -1 males, 0 females 3 years old
    0 males, -1 females 4 years old
    -1 males, 0 females 5 years old
    0 males, -1 females 6 years old
    -9 male, -13 female adults (age > 7)

Deterministic population growth rate:
     r =       0.028
     lambda =  1.028
     R0 =      1.767
     Generation time =  20.60
In 100 simulations of 100 years:
1.    0 populations went extinct and 100 survived.
This gives a probability of extinction of      0,
  or a probability of success of 1.0000.
2.    Mean final population for successful cases was   66.20,
  with a standard deviation of    9.99.
3.    During 1 years of harvest/supplementation
  mean lambda was 0.5784, with standard deviation  0.0617.
4.    Without harvest/supplementation, prior to carrying capacity truncation,
  mean lambda was 1.0304, with standard deviation  0.0596.
```

Table 15. Javan rhinoceros - a growth scenario for the Ujung Kulon population reduced below carrying capacity.

K = 75	T = 100 yrs	
EV = 1, 1, 1	Catastrophes = 0.1,0.9	
Fertility:	67%=0	33%=1
Mortality: Inf = 10%, Juv = 2%, Ad = 6%		
P Surv = 1.000	Lambda = 1.033	
GT = 20.6	N = 67 ± 7	

Table 16. Population projections with removals and catastrophes in a population that responds with an increase in growth rate.

Scenario (N)	Years 0	20	40	60	80	100	P [Surv]
Basic	56	70	72	71	70	69± 6	1.000
EV 10,10,10	56	39	38	38	32	38±17	.550
EV 3, 3, 3	56	61	62	61	60	62±10	1.000
CV .1, .9	56	62	65	64	63	67± 7	1.000
CV .1, .9 & .5, .98	56	64	66	65	66	66± 9	1.000
CV .1,.9 & .5,.98 & EV = 3,3,3	56	46	41	38	36	35±18	.901
Rem 1/2 A & Y	26	61	64	66	66	66±10	1.000
CV .1,.9	26	52	55	55	55	57±14	1.000
Rem over 2 years CV .1,.9, .5,.98	30	54	60	62	62	62±12	.998

500 RUNS. K=75. Mortality: I=10%, J=2%, A=6%.

The standard errors of survival probabilities (given by P x [1 - P] / sqrt[# runs]) are typically about .005, and standard errors around the number of rhinos in surviving populations ranged from about 1 to 5. In all cases examined the asymptotic stable age distribution just prior to each breeding season was 6-10% 1-year old rhinos: 28% sub-adults between 1 and 7: 60% breeding-age rhinos. This distribution differs from that observed at Ujung Kulon (e.g., calves comprised about 4-5% of the census in the past 5 years).

Modest annual environmental variation at Ujung Kulon does not have much impact on the probability that the population will survive 100 years (though it does affect the sizes of the persisting populations). With the observed zero to small positive mean growth rate, moderate environmental variation would not be sufficient to cause extinction. However if the character of the environment changes over time with expansion of bantang populations or removal of timber the impact of environmental variation upon the rhinoceroses may also change. More information on the ecological requirements of the species will be of value to assess these possibilities.

The predominant demographic factor controlling extinction rates is the frequency of modest catastrophic mortality as might be caused by poaching or a localized disease epidemic or a short term reduction in food supply. The modest growth rate of the Ujung Kulon population is likely to be insufficient to assure that the population will recover from one catastrophe before the next one occurs. The mean time to extinction (of those simulated populations that go extinct within 100 years) for almost all scenarios was approximately 85 years, with extinctions accumulating over the 100 years. It appears that simulated populations regularly declined and increasingly many went extinct as years progressed and indeed if many of the simulations were extended to 200 years many more populations would go to extinction.

The effects of poaching and catastrophes such as disease outbreaks on the probability of survival depend significantly on the carrying capacity and growth rate of the population at the low population levels at Ujung Kulon. The existence of other independent populations would reduce the probability of extinction as a product of the individual population probability estimates. If catastrophes are as frequent as has been estimated and become more severe, then a population often will not reach the carrying capacity before being reduced again. The effect of catastrophes on population survival is highly dependent upon the growth rate of the population, with more slowly growing populations being especially vulnerable (presumably because they rarely recover from a catastrophe before another strikes the population).

If several populations of Javan rhinos existed at a sufficient distance from one another to minimize the chance that a single catastrophe would decimate both, the probability that all would perish within 100 years would be equal to the product of the probabilities that each would go extinct, if no recolonization from extant populations followed local extinctions. Thus if the populations are independently vulnerable and each has a probability of extinction of 0.2 then the joint probability of simultaneous extinction is (0.2 x 0.2) = 0.04. The likelihood of extinction is dramatically reduced with active management plans that include recolonization of areas depleted of rhinos from other populations whether wild or captive.

Demographic Recommendations

Additional sites:

The primary risk to the Javan rhinoceros at this time seems to be the chance that modest catastrophes will continue to strike the population and that it will continue to lose genic diversity because of its small and varying effective population size. The wild population seems sufficiently large so that, in the absence of a sudden population decimation, the modest growth rate as experienced over the past ten years will prevent random fluctuations in birth and death rates (demographic and environmental variability) from driving the population to extinction. The probability that a disease outbreak or some other natural catastrophe will decimate the population is very difficult to estimate. The perhaps conservative guesses about the frequency and effect of disease and poaching made by participants in the PVA workshop were found to lead to extinction probabilities that we find unacceptably high. The simulation results support the view expressed in the points of agreement that a primary and urgent goal of the program should be to establish captive and additional wild populations of the Javan rhinoceros as soon as possible.

Given that no one wild population of rhinos is likely to provide sufficient security for the survival of the species and that no single wild population is likely to be larger than 100 animals we would recommend that long term plans be made (this need has been addressed in the Asian Rhino Specialist Group Action Plan) to secure 20 wild sanctuaries with a total capacity of at least 2000 animals for this species throughout its historic range.

Given that the most urgent need for protection and conservation of the Javan rhinoceros is to expand its numbers as rapidly as possible we recommend that up to one-half the animals be removed from the wild population at Ujung Kulon to establish 3 captive populations. This would provide up to 26 founder animals for the captive population.

The total captive population should be expanded to 150 - 200 animals as rapidly as possible. This action will protect against continuing lose of genic diversity and afford protection against demographic loss of the species. The growth potential of the current wild population appears to be constrained by its carrying capacity. It is likely that with removal of these animals from the wild population and continuing protection that the population will replace these animals within 10 - 15 years as occurred during the growth period 1971 - 1981.

The new sites for rhinoceroses should be off the island of Java, so that they are outside of the likely path of severe destruction of any storm that may hit the island or a disease epidemic. One of these sites would best be located near or within the first large planned release or reintroduction site. This site will require construction of facilities that are adequate for holding and managing about 25 - 30 animals. The development of captive rhino management expertise and a rhino team for capture of the animals and later for conducting and monitoring a release program are essential. There will be a need at Ujung Kulon to undertake radiotelemetry studies of animals that are captured and released as a part of a systematic program to learn more about the population dynamics of this population and the ecology of the species. Such information can provide important guidance for the reintroduction program.

Efforts should begin immediately to identify a captive breeding facility in Indonesia that has experience and success in breeding rhinoceros, that has good quarantine facilities, and that can give them intensive management.

The timetable for moving rhinos to the chosen sites is constrained by site selection, by construction schedules, the need to assemble an experienced capture team, the need for holding facility, and costs. The schedule for capture and moving rhinos must be a compromise between the urgent need for establishing populations that are isolated from Ujung Kulon and the need to avoid placing a substantial number of rhinos in tested facilities that may harbor unknown disease vectors or have other unforeseen management problems. There are significant risks associated with a capture, holding and transport operation as has been found with the Sumatran rhinoceros operations in Indonesia, Malaysia, and Sabah.

While the captive populations will provide back-up in case of catastrophe (and allow more opportunity for experimentation with varied management approaches), longer-range recovery plans should address the need for at least 10 reasonably independent populations of rhinoceroses in Indonesia and other countries in the historical range of the species. Only after Javan rhinoceroses are well-established in multiple sites (5 or more) could the risk of extinction be considered low enough to permit easing of recovery efforts (the ultimate goal of any recovery planning).

Interactive demographic management of the wild and captive populations:

The wild population of Javan rhinoceroses in Ujung Kulon and those populations to be established in the next 25 - 50 years are likely to be at such low numbers that extinction of individual populations will be a continuing threat. As the computer modelling demonstrates, the chance that a disease or other catastrophe will eliminate a rhinoceros population is critically dependent on the rate of growth of that population and is strongly dependent on the initial size of the population.

Because of this continuing risk and uncertainty we would recommend that high priority be given to maintenance of a dispersed thriving captive population. Wild populations of many species, endangered and otherwise, are subject to so many risks that any one has a relatively short expected duration. Black-footed ferrets, California condors, and whooping cranes are just a few of the better known examples of wild populations being decimated very quickly. Captive populations do not always thrive, but they also rarely are exterminated quickly, especially if divided among multiple locations. Mortality is generally very low in captive facilities with experience in propagating a species (as is the case for now for the Indian rhinoceros). This low mortality can "buy time" while husbandry methods for enhancing reproduction are developed (hence the lower probability of sudden extinction). Improvements in the management of the wild population may also assist that population, but dramatic increases are unlikely.

Given that highest priority should go toward increasing numbers of rhinoceroses by whatever means are available, we favor retaining most or all of captive-produced rhinos in the captive breeding program until the population goals of the captive program are met. If captive production is faster than production in the wild, the quickest route to a secure wild and captive population is to use the captive population as a short-term, high-investment production facility. Slowing growth of the captive populations will likely lead to costly delays in progress toward full recovery of the species.

Our recommendation to retain rhinos in captivity until the captive population is large and secure has a qualifier. In the event of disastrous events in the wild, the wild population should not be allowed to perish if that can be prevented without also sacrificing the captive population. Unlike the case with the Arabian oryx, Przewalski's horse, California condor, red wolf, and black footed ferrets, the rhinoceros recovery program has the very important advantage of having a wild population of experienced animals.

If no catastrophe strikes, the wild population is likely to recover from the removals even if there is no input from the captive population. If a natural disaster or disease does decimate the wild population of rhinoceroses, a large captive population as a source for replenishment or reestablishment will likely be far more important to the recovery of the wild population than will additional animals in the pre-catastrophe wild population.

PROJECT PROPOSAL FOR AN INVESTIGATION INTO THE ECOLOGY AND BEHAVIOUR OF BANTENG WITH PARTICULAR REFERENCE TO THEIR INTERACTIONS WITH WATER BUFFALO, RUSA AND JAVAN RHINOCEROS IN BALURAN AND UJUNG KULON NATIONAL PARKS, JAVA

TO BE CONDUCTED IN COLLABORATION WITH THE FORESTRY AND NATURE CONSERVATION PROJECT OF THE NETHERLANDS-INDONESIAN INTER UNIVERSITY PROGRAMME OF COOPERATION

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OVERVIEW

This document contains a proposal for a three-and-a-half year long in depth investigation of the ecology and behaviour of banteng (*Bos javanicus*) an endangered species of wild cattle. Particular attention will be paid to the interactions between banteng, feral water buffalo (*Bubalus bubalis*) and rusa (*Cervus timorensis*) in Baluran National Park in East Java and between banteng, rusa and Javan rhinoceros (*Rhinoceros sondaicus*) in Ujung Kulon National Park in West Java. This research is necessary since it is feared that the banteng population within Baluran is in decline as a result of competition for food and water with the water buffalo and conversely that the banteng population in Ujung Kulon may be outcompeting the rhino - the world's rarest large mammal. The study will allow informed management guidelines to be written for the ungulates in these internationally important national parks.

The proposed investigation will be carried out in collaboration with the Forestry and Nature Conservation Project (FONC) of the Netherlands-Indonesian Inter University Programme of Cooperation and will involve staff and students from the Department of Nature Conservation at Wageningen Agricultural University in the Netherlands; the Fakultas Kehutanan, Universitas Gadjah Mada in Yogyakarta, Java; and the Department of Biology at Southampton University in the United Kingdom.

The research described in this document will be carried out by an ecologist from Southampton University: Simon Hedges who has experience of field work in Indonesia and speaks Bahasa Indonesia. Another ecologist from Southampton, Martin Tyson, will act as a research assistant. Three Indonesian botany students will also be involved in the project as counterparts.

INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

SECTION 4 - GLOBAL HERITAGE SPECIES PROTOTYPE

INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

SECTION 5 - SUMATRAN RHINO BACKGROUND MATERIAL

Figure 2a Approximate former distribution of the Javan rhinoceros (shaded area).

effective carrying capacity of the area. One danger to these animals comes from disease, which could potentially wipe out the entire population. In 1981-1982, this threat became a reality when an unknown disease actually killed at least five animals in Ujung Kulon. In addition, any such small population of rhinos faces a permanent threat from poachers. There are no Javan rhinos in captivity.

Figure 2b Current distribuition of the Javan rhinoceros. 1: Ujung Kulon; 2: Nam Cat Tien; 3: Bugiamap. Note: the records mapped in Laos and Kampuchea refer to scattered sightings, and it is not clear whether any of these constitute substantial populations.

It is suggested that the situation facing this species be looked at very closely to see if recommendations to translocate some animals into other areas, such as Way Kambas or southern part of Bukit Barisan Selatan National Park in Sumatra should not be seriously considered. A single small population is always extremely vulnerable. It must be kept in mind that the Ujung Kulon peninsula is on the Sundaic edge volcanic line and that during the Krakatau eruption in 1883, the entire peninsula was affected by tidal waves and ash rains which destroyed much of its terrestrial life.

A second approach is that the Indonesian authorities should also consider bringing some animals into a captive breeding project to be based at least partly in Indonesia.

Better exploration of the situation in Vietnam, Laos and Cambodia also needs to take place, with the option of captive breeding again being considered. Such information might become available as fieldwork on the kouprey *Bos sauveli* conservation programme get underway.

2.3 The Sumatran Rhinoceros

The Sumatran rhinoceros was once found from the foothills of the Himalayas in Bhutan and eastern India, through Burma, Thailand, and the Malay Peninsula, and on the islands of Sumatra and Borneo. There have also been unconfirmed reports of the species in Cambodia, Laos and Vietnam. The past and present distributions are displayed in Figures 3a and 3b and population estimates are given in Table 3. In general this species has survived much better in its native habitats than the Javan rhino. This may be partly because it mainly inhabits the mountains and forests of higher elevations which were not so subject to development and logging. In contrast the Javan rhino is a species of the coastal plains and river valleys.

At present the species survives in pockets in Burma, Thailand, the Malay Peninsula, Sumatra and Borneo. Little is known of its status in Burma which holds the subspecies *lasiotus*. The nominate subspecies *sumatrensis* is now represented by animals in Thailand, Peninsula Malaysia and in Sumatra. There has been little recent news of animals in Thailand and its continuing occurrence there is now in doubt. In the Peninsula there are an estimated 100 animals surviving in several isolated pockets of which perhaps only two are in protected areas of sufficient size to guarantee long term viability. All these animals have to be closely protected.

The largest number of the subspecies *sumatrensis* now survives on the island of Sumatra and it is possible that several hundred animals still exist. However, the island is now in a phase of intense development resulting from Indonesia's transmigration programme and the habitat available to the species is being rapidly reduced. In addition the sheer size of the island, compared to the available staff for protecting the species, makes adequate protection almost impossible. Even in areas where there is a strong presence of protection staff, poaching is active. This is evidenced by the fact that in a project to capture animals for a captive breeding programme in an area where numerous wildlife staff are positioned, animals are being caught with fresh snare wounds on their legs.

The rhinos in Sumatra are too widespread and in too many pockets for all of them to be protected adequately in the ranges where they still survive. As a result, they are subject to

Table 3. Population estimates of the Sumatran rhinoceros

Country	Location	No of Rhino	Habitat Availability Presently (Km²)	Habitat Availability Potentially (Km²)	Protection Status	Potential Carrying Capacity
Burma	Schwe-u-daung	Perhaps survives	207	?	Game sanctuary	?
Burma	Tamanthi	Perhaps survives	2,150	?	Game sanctuary	?
Burma	Lassai tract	6-7	?	?	Unknown	?
Indonesia (Kalimantan)	near Sabah border	Perhaps survives	?	?	Unclear	?
Indonesia (Sumatra)	Gunung Leuser	130-200	1,400	8,000	National Park but disturbance & poaching	140-800
Indonesia (Sumatra)	Gunung Patah	Numbers unknown	400	500	No information	40-50
Indonesia (Sumatra)	Kerinci Seblat	250-500	5,000	10,000	Little protection proposed National Park	500-1,000
Indonesia (Sumatra)	Gunung Abong-abong and Lesten-Lukup	15-25	?	?	Not protected	?
Indonesia (Sumatra)	Berbak	Perhaps extinct	?	?	Nature Reserve	?
Indonesia (Sumatra)	Torgamba	Very few	?	?	Being deforested	?
Indonesia (Sumatra)	Barisan Selatan	25-60	700	3,600	National Park, deforestation occurring	70-360
Malaysia (Peninsula)	EndauRompin	10-25	1,600	1,000-1,600	Reserve, National Park proposed	110-160
Malaysia (Peninsula)	Taman Negara	22-36	4,400	4,400	National Park	220-440
Malaysia (Peninsula)	Sungai Dusun	3-4	40	140 +	State Wildlife Reserve	15
Malaysia (Peninsula)	Gunung Belumut	3-5	230	230	Wildlife Reserve proposed	23
Malaysia (Peninsula)	Mersing Coast	5-6	?	Probably none	Being deforested	0
Malaysia (Peninsula)	Sungai Depak	2-4	?	Probably none	Being deforested	0
Malaysia (Peninsula)	Sungai Yong	3-5	?	Probably none	No information	0
Malaysia (Peninsula)	Kuala Balah	2-4	?	Probably none	Being deforested	0
Malaysia (Peninsula)	Bukit Gebok	?	?	None	Being deforested	0
Malaysia (Peninsula)	Krau Reserve	1	500	500	Insecure	50
Malaysia (Peninsula)	Sungai Lepar	2	1,000	0	Unprotected and being deforested	0
Malaysia (Peninsula)	Ulu Atok	1	?	?	No information	?
Malaysia (Peninsula)	Ulu Selama	6-7	?	?	Unprotected	?
Malaysia (Peninsula)	Ulu Belum	2-4	?	?	Insecure	?
Malaysia (Peninsula)	Bubu Forest	2	?	?	No information	?
Malaysia (Peninsula)	Kedah	1	?	?	Insecure	?
Malaysia (Sabah)	Tabin Reserve	20 +	1,200	1,200	Perhaps protectable	120
Malaysia (Sabah)	Kretam/Dent Peninsula	8	1,000	0	Being converted to agriculture	0
Malaysia (Sabah)	Danum Valley	10	2,000	2,000	Perhaps protectable	200
Malaysia (Sarawak)	Limbang	5-15	600	600	Protection proposed	60
Thailand	Phu Khieo	Perhaps survives	1,560	?	Protected area	?
Thailand	Tenasserim Range	6-15	?	?	Insecure	?
Thailand	Khao Soi Dao Reserve	Perhaps survives	745	?	Protected area	?
TOTAL			**536-962**			**1,548-3,278**

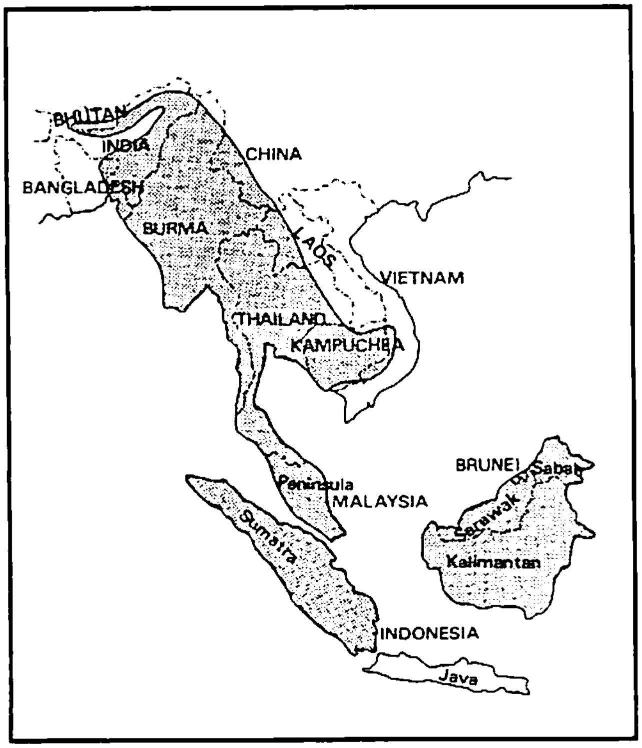

Figure 3a Approximate former distribution of the Sumatran rhinoceros (shaded area).

Figure 3b Current distribution of the Sumatran rhinoceros. 1: Lassai tract; 2: Tamanthi; 3: Schwe-u-daung; 4: Phu Khieo; 5: Khao Soi Dao; 6: Tenasserim Range; 7: Kedah; 8: Ulu Selama; 9: Bubu Forest; 10: Kuala Balah; 11: Sungai Depak; 12: Sungai Yong; 13: Taman Negara; 14: Sungai Lepar; 15: Ulu Atok; 16: Ulu Belum; 17: Sungai Dusun; 18: Krau Reserve; 19: Bukit Gebok; 20: Endau Rompin; 21: Mersing Coast; 22: Gunung Belumut; 23: Lesten Lukup; 24: Gunung Abongabong; 25: Gunung Leuser; 26: Torgamba; 27: Berbak; 28: Kerinci Seblat; 29: Gunung Patah; 30: Barisan Selatan; 31: Limbang; 32: Kretam; 33: Tabin; 34: Danum Valley; 35: Sabah border.

Sumatran rhinoceros
(Photo: Department of Wildlife and National Parks, Malaysia)

heavy poaching pressure both from hunters with firearms and from trappers who use wire snares and other traps that maim and kill animals. The total world population is now thought to be between 500 and 900 animals (see Table 3) and the annual loss may be as much as 10 percent of that population. There is evidence that breeding in the wild is taking place but the rate of such recruitment to the population is not known. Presently, there are 16 animals in captivity.

The subspecies *harrissoni* is possibly the most endangered of the subspecies and now exist in a few rapidly dwindling pockets in eastern Sabah. There may be less than thirty animals still surviving in the state and the rate of poaching is believed to be high. The Sabah state is at present engaged in a programme to capture these high risk animals and put them into the safety of a captive breeding programme. Recently it was discovered that a small group of this subspecies survives in the upper Limbang catchment in Sarawak. Efforts are now being made to monitor this group and protect them from poachers. It is also possible that populations remain in eastern Kalimantan.

An extensive international cooperative programme for the conservation of this species is already being implemented. There are ongoing efforts to establish captive breeding centres for the species in Indonesia and in Malaysia (both the Peninsula and in Sabah) where the active trapping of animals is now being carried out. Captive breeding is also being planned in the United States and the United Kingdom, using animals of Indonesian origin. The Peninsular Malaysian programme also calls for the setting up of "gene pools" where the species will be allowed to breed in semi-wild conditions in large fenced areas.

All of these efforts are components of a global captive propagation programme being developed for this species under the general guidelines of the Singapore Proposals (see Appendix 2) adopted by the Asian Rhino Specialist Group (ARSG) and IUCN in 1984 and in accordance with the specific provisions of the national plans and bilateral agreements that have been formulated. A major guideline of note is that no mixing of animals from the four major regions of their range (Burma, Peninsula, Sumatra, and Borneo) be undertaken until there has been adequate genetic investigation of any significant differences between these geographically disjunct populations.

2.4 Conclusion

Finally, it should be emphasised that members of the IUCN/SSC Asian Rhino Specialist Group should work together for the maximum benefit of all these species, and should carry out their tasks and agreements in a manner that will encourage and engender future and long-term cooperation. The importance of respecting absolutely the authority in each country that is responsible for the conservation of wildlife in general, and the rhino species in particular, cannot be overemphasised.

Great one-horned rhinoceros (Photo: Peter Jackson)

3. The Great One-horned Rhinoceros: An Action Plan

3.1 Introduction

The past and present status of this species is summarised in Chapter 2. The total estimated number is around 1,700 animals. The species has been well protected by the Indian and Nepalese wildlife authorities and the situation had seemed to be under control. However, the increasing human population pressure and the poverty of the villagers who surround these rhino sanctuaries, coupled with the great value of its horn, have resulted in significant losses to poachers in India and this still poses a threat to rhinos in Nepal. At present, the poaching in India is being brought under control.

The emphasis of this action plan is to consider what needs to be done to preserve the species in perpetuity. Thus, the main objectives that should govern immediate conservation actions are detailed along with specific recommendations derived from these objectives. Application of these recommendations is considered separately for Nepal and India.

3.2 Objectives

1. To maintain a total wild population of at least 2,000 rhinos.

2. To maintain these rhinos in at least six major sanctuaries in the current range of the species: Kaziranga, Manas, Orang and Dudhwa in India; Chitawan and Bardia in Nepal.

3. To expand this number of rhinos and sanctuaries when and where possible.

4. To respond to specific threats to viable populations in the wild (especially anti-poaching measures) as required.

5. To maintain a captive population capable of long-term viability to guard against any unforseen extinction of the wild population.

6. To continue efforts to close down the trade in rhino products.

3.3 General Recommendations

1. Concentrate efforts on areas in which reasonably viable wild populations (> 100 rhinos) in the wild can be established:

   India: Kaziranga
   Manas (partly in Bhutan)
   Dudhwa
   Orang

   Nepal: Chitawan
   Bardia

   Such efforts should include anti-poaching measures, training of staff, public education campaigns, ecological studies and population monitoring. In addition, methods which allow local people to benefit from the existence of the rhinos (such as tourist revenues) should be investigated.

2. Calculate the resources currently available and those additionally required to provide adequate protection for these populations. Develop project proposals to donors for the additional resources, as needed.

3. Assess the value to the conservation of the species of the small remnant populations of rhinos, e.g. Jaldapara, through better information on current status and cost-benefit analyses of increased protection and management in such areas.

4. Conduct biochemical and genetic studies to determine whether the now disjunct populations in the Terai and the Brahmaputra Basin constitute evolutionarily significant units (ESUs) justifying preservation as separate entities. Encourage zoos to provide tissue and blood from their animals to begin these investigations as soon as possible.

5. Continue efforts to establish other wild populations elsewhere in India and Nepal through translocations. But such translocations should be limited to sanctuaries where the carrying capacity exceeds 100 rhinos. It is recom-

This is a very high priority, which should follow on from the captive breeding programme. The area to be selected should be within the historical range of the species, with suitable habitat for the animals to survive at a relatively high density, of sufficient size to support a viable population, and with good security against poachers.

6. **Enforce strict measures to prohibit the use of Javan rhino products in Indonesia.**

This is to include the application of the strongest possible penalties against poachers and traders.

4.5 Vietnam, Laos and Cambodia: Specific Recommendations

Because of the very uncertain situation of this species in Indochina, only recommendations number three and six apply at this stage. Surveys should be coupled with the Kouprey Conservation Programme, and probably will not require additional funding. A survey in Nam Cat-tien National Park and Bugiamap Reserve in Vietnam is of particular importance. An internal ban on the use and marketing of rhinoceros products in Laos is also needed.

4.6 Conclusion

A recovery programme for the Javan rhinoceros is one of the most pressing species conservation priorities in the world. The loss of this species would be a supreme act of negligence on behalf of the conservation community.

5. The Asian Two-horned or Sumatran Rhinoceros: An Action Plan

5.1 Introduction

The Sumatran rhinoceros is a species of rainforest in hilly and mountainous areas. It is much more widely scattered, often in tiny inviable populations, than the other two species. As a result, it is more difficult to make decisions as to the most appropriate priorities for its conservation, especially since a number of national and state governments are involved. Although not yet as critically threatened as the Javan rhinoceros, this species is probably experiencing the most serious level of poaching for its horn of all the Asian rhinos. In some areas it is also threatened by habitat destruction. In view of these complexities, it has been felt best to handle the specific recommendations for each country in a slightly different way from the previous two species.

Development of captive populations in North America and England, as well as in the countries of origin, is considered important for several reasons:

1. There are significant risks (e.g. disease epidemics, natural disasters, etc) of having all the rhinos in only a few places.

Sumatran rhinoceros
(Photo: Department of Wildlife and National Parks, Malaysia)

To ensure maximum security, the population should be distributed as widely as possible.

2. For long-term viability, the captive population needs to be larger than existing South-east Asian facilities can reasonably accommodate.

3. There are appreciable resources and expertise in North American and British zoos that can be utilized to expedite the expansion of the captive population.

However, it should also be noted that for a variety of reasons the mortality among animals that have been transported beyond the borders of their countries is extremely high. Of the five animals moved so far three have died, a 60 percent mortality. This does not compare well with the overall mortality of the capture programme in which five animals have died out of 17 captures (29.4 percent). In fact the mortality falls to 15.4 percent (two mortalities out of 13 animals) if the mortalities of exported animals are excluded from the calculations.

Therefore, it is essential that certain conditions be satisfied when animals are to be transported to foreign destinations. These are:

1. There must be accurate and as complete information on the animal/animals as possible. This should include complete veterinary records.

2. The animals should not only be in excellent health but should be free from any significant physical deformities or injuries. As far as possible the animals should be in perfect condition.

3. The animals should be physically prepared for their new homes and should be preconditioned, at least partially, to the new diet regime before they are moved.

5.2 Objectives

1. To develop populations of at least 700-1,000 rhinos in each of the major regions of its range: Sumatra, Borneo, Peninsular Malaysia and adjacent mainland, and northern Burma.

2. To preserve, manage and where appropriate expand all populations that have the potential to increase to 100 animals or more.

3. To determine if the populations in each major part of its range (listed under objective 1 above) constitute valid subspecies or evolutionary significant units (ESUs), justifying preservation as separate entities by conservation programmes.

4. To locate or establish additional viable populations, especially on the mainland and Borneo..

5. To develop a captive population of 150 rhinos distributed in zoos worldwide: South-east Asia, North America, and Europe. Establish this captive population with at least 20 pairs of founders from the wild.

6. To experiment with the gene pool concept.

7. To continue efforts to close down the trade in rhino products.

5.3 General Recommendations

1. Concentrate initial *in situ* conservation efforts on the seven, or so, populations considered to be reasonably viable according to current information and analysis (see Table 3).

2. Calculate the resources currently available and additionally required to provide adequate protection for these populations.

3. Ensure improved legal protection status of all areas with viable, or potentially viable, populations (particular attention to be given to Kerinci-Seblat in Sumatra and Endau Rompin in Peninsular Malaysia).

4. Conduct biochemical genetic studies, initially using blood and tissue from captive animals, to investigate if there is more than one ESU in this species.

5. Organise surveys as soon as possible in Kalimantan (highest priority), Thailand, and northern Burma to ascertain whether appreciable populations of rhino survive there.

6. Continue the capture of "doomed" animals to provide founders for the captive population and the gene pool experiments, as well as stock for possible translocation after sufficient animals have been obtained for the *ex situ* programmes.

7. Develop an experimental "gene pool" in order to learn as much as possible about the management of the animals (initially at Sungai Dusun in Peninsular Malaysia).

8. Manage the captive animals as part of the overall conservation programme for the species, and discourage all movements of captive rhinos (including as gifts), unless this is endorsed by IUCN. Details on how the animals should be managed in captivity are available from the ARSG. Guidelines for captive management are given in Appendix 3.

9. Improve the effectiveness of law enforcement throughout the species' range with respect to anti-poaching measures and trading in Sumatran rhinoceros products. The strictest possible penalties should be applied to offenders.

5.4 Indonesia: Specific Recommendations

The total population of the Sumatran rhinoceros in Indonesia is estimated to be between 420-785, all in Sumatra, with the possibility of a few existing in Kalimantan (see Table 3).

In Indonesia this species has been legally protected since 1931. A number of reserves have been set aside for the conservation of wildlife, including this species, notably the Gunung Leuser, Kerinci-Seblat, and Barisan Selatan National Parks in Sumatra. These are all managed by the PHPA (Perlindugan Hutan dan Pelestian Alam), a Directorate General which comes under the Ministry of Forestry.

A programme of bringing animals into captivity is currently underway for doomed rhinos in Sumatra. This is being organised by the American Association of Zoological Parks and Aquaria (AAZPA), and the Howletts and Port Lympne Zoo in Britain. This programme is still in an early Phase, but it is envisaged to include captive breeding in Indonesia, Britain and the United States.

The goal is to ensure the survival of viable populations of the Sumatran rhino in Indonesia in its natural habitat.

1. Protection

Better protection is needed of the known viable rhino populations in Kerinci-Seblat, Gunung Leuser and Barisan Selatan National Parks in Sumatra. Such improved protection should include the following aspects:

- an increase in anti-poaching efforts;

- appropriate forms of sustainable development in the buffer-zones around these parks, to enable people to derive economic benefits from the protected areas;

- a public education programme on the importance of these national parks and their rhinos;

- a training programme for all levels of staff working in wildlife and protected area management. This should include training in captive management of rhino;

- formal gazettment of the national park at Kerinci-Seblat.

2. Monitoring

Monitoring should be done on as many rhino populations as possible on a regular basis to assess the trends, distribution, movement and habitat preferences of the species. Censusing should preferably be carried out annually by teams of people following standardised methods. Surveys also need to be carried out to determine the distribution and abundance of the species outside the protected areas. In particular, surveys should be carried out to assess the status of rhino, if any, in Gunung Patah, Gunung Abongabong, Lesten-Lukup, and in Kalimantan (along the border with Sabah, and northern Sarawak opposite the upper Limbang catchment).

3. Capture and translocation

It is important to identify areas that are destined to be converted to other land uses incompatible with wildlife conservation, and hence determine whether it is necessary to translocate rhinos to another, safer area or into the captive population. The target area must have adequate habitat to sustain a viable population of rhino. For the management of captive animals in Indonesia, the principles outlined for Malaysia, and in Appendix 3, apply.

4. Research

Research on rhino populations in the national parks and other protected areas should be carried out with a view to determining their number, breeding performance and habitat requirements. It is also necessary in order to determine the threats to the animals in each area and to devise appropriate conservation action.

5. Trade

It is clear that an illegal trade exists in Sumatran rhino horn, from Sumatra to Singapore and possibly other countries. It is recommended that the governments concerned make a concerted effort to bring the situation under control. This trade is probably the most serious threat to the species at the present time.

5.5 Malaysia: Specific Recommendations

The management of wildlife in Malaysia is governed by three different legislative measures. In the Peninsula, the Wildlife Protection Act of 1972 provides wildlife protection for the 11 states. In Sabah and Sarawak, the Fauna Conservation Ordinance and the Wildlife Protection Ordinance make necessary provisions for wildlife administration respectively. The Sumatran rhino is protected by law throughout Malaysia. Of 20 known populations in Malaysia, 16 are considered inviable and only four (Taman Negara, Endau Rompin, Tabin and Danum Valley) are considered reasonably viable for long-term genetic management. Habitat destruction through logging, agricultural development, human settlement, and shifting cultivation are the main causes of the population decline. Poaching has been brought under control in the Peninsula but remains a serious problem in Sabah.

The goal is to maintain viable populations of the Sumatran rhinoceros in the wild in Malaysia. The objectives of the action plan for Malaysia are:

- to protect and manage the rhino and its habitat;
- to gather information on the viability of the populations and exact habitat requirements for rhinos;
- to promote scientific research and dissemination of information on captive individiuals;
- to build up the captive population so as to make animals available for reintroduction.

1. Sabah

a. Wildlife conservation and management in the state of Sabah is the responsibility of the Wildlife Division of the Forestry Department. The current strength of the Division is inadequate for effective protection and research to be conducted for the rhino in particular and wildlife in general. As a long-term measure, the Wildlife Division should be strengthened in terms of staffing, funding and logistical support.

b. The Fauna Conservation Ordinance 1963 is the wildlife legislation for the state of Sabah. Current penalties for poaching of rhinos and relevant provisions are considered inadequate to deter poaching or to ensure that offenders are brought to book. It is therefore recommended that the ordinance be reviewed to provide for heavier penalties for poaching of rhinos, and the powers of wildlife officers be reviewed to enable them to carry out their duties effectively.

c. Currently, only three breeding populations of the Sumatran rhino are known in Sabah, in the Tabin Wildlife Reserve, the Danum Valley Conservation Area, and the Kretam area (although there are other scattered records from south-eastern Sabah). The status of these three areas needs to be reviewed to determine how much land and habitat needs to be protected. In addition, sufficient manpower and facilities should be assigned to these two areas. Public education programmes should be instigated around these areas, and appropriate forms of buffer-zone development should be considered.

d. At least two of the known populations are considered to be reasonably viable for long-term genetic management (Tabin has approximately 20, and Danum about 10 individuals). It is recommended that surveys be conducted to determine whether further breeding populations exist, and to locate other isolated individuals.

e. It is recommended that the capture of isolated or threatened rhinos be continued for captive breeding or translocation purposes. Breeding between individuals from different geographical regions (e.g. Peninsular Malaysia and Sabah) should be avoided (unless further studies show that there are no appreciable genetic differences between these areas).

2. Sarawak

a. A detailed study of the rhino population is needed in order to demonstrate that the area should be declared a national park or a rhino reserve.

b. Constant monitoring of the Ulu Limbang population is needed to determine its true extent, and its protection requirements.

3. Taman Negara and Endau Rompin (Peninsular Malaysia)

a. These are the two viable populations in Peninsular Malaysia. Constant surveillance should be carried out on these populations. As a matter of the highest priority, the state governments of Pahang and Jahare should be encouraged designate Endau Rompin as a National Park.

b. Extensive habitat evaluation should be carried out to determine the carrying capacity of the areas. This information is important to determine whether these are suitable sites for the future release of animals translocated from doomed populations.

4. Sungai Dusun Wildlife Reserve (Peninsular Malaysia)

a. The "gene pool" concept, in which rhinos would be managed in a semi-wild state, should be implemented at this site. The founder population may consist of five breeding females and at least two sexually mature bulls.

5. Malacca Zoo (Peninsular Malaysia)

a. A captive breeding stock of at least two males and four females should be established.

b. The ARSG should pool all essential data from attempts at captive breeding of the species (including from attempts outside Malaysia) in order to ensure that maximum possible use is made of the limited supply of animals. Such data would include aspects of physiology, pathology, parasitology, feeding, growth and reproduction. The computer database facility at Malacca needs to be upgraded for this purpose. This database would be of use to other breeding facilities at Sungai Dusun, Tabin, Ragunan Zoo, Los Angeles Zoo and Howletts and Port Lympne Zoo. In this way, Malacca Zoo would act as a reference centre for the overall captive breeding programme.

6. Other areas in Peninsular Malaysia

a. Rhinos in isolated and threatened areas will be captured for the "gene pool" and captive breeding programme at Malacca zoo. When these facilities have reached the maximum holding capacity, the newly captured animals could be relocated in Taman Negara and Endau Rompin. It is also proposed that the Malaysian animals largely be kept within the country for the time being for the following reasons:

- That no mixing of animals from the four major regions of their range (Burma, Peninsula, Sumatra and Borneo) be undertaken until there has been adequate genetic investigation of any significant differences between these geographically disjunct populations.

- That all the animals now currently being caught are prioritised for the captive breeding and gene pool programme, which will require between 10 and 20 animals. Once sufficient animals are available for the breeding programmes in the Peninsula, and if it can be shown that they are genetically similar to animals from other areas, then further animals, if caught, could be considered for overseas captive breeding programmes.

5.6 Thailand

The current status of the species in Thailand is obscure, and requires investigation. If any animals survive, it is most unlikely that they do so in viable populations. As such, any animals would best be captured for a captive breeding programme (perhaps in conjunction with Peninsular Malaysia), pending reintroduction to a suitable site at a later date.

Rhino products, almost entirely of imported origin, are still available in Thailand. Although rhinos are strictly protected in Thailand, there is currently insufficient legal capacity to control the importation of rhino products. The government of Thailand is strongly urged to take action on this.

5.7 Burma

That the isolated subspecies *lasiotus* survives in northern Burma is confirmed by the continuing appearance of rhino products of Burmese origin in northern Thailand. As the situation permits, the status of the species in northern Burma should be investigated to determine the necessary *in situ* and *ex situ* conservation requirements.

5.8 Conclusion

The Sumatran rhino is an instance of a species where there is still time to act to reverse the current rapid decline in the population. Current efforts at all levels must therefore be intensified if a "Javan rhino" type crisis is to be avoided.

SUMMARY OF GLOBAL PROPAGATION GROUP MEETING
SUMATRAN RHINO
SAN DIEGO CA - 11 MAY 1991

Present: *Amato, Burnette, Doherty, Dresser, Foose, Furley, Khan, Lukas, Lusli, MacKinnon, Maruska, Miller, Mustafa, Prasetyo, Reece, Santiapillai, Sullivan, Widodo*

The first meeting of the Global Propagation Group for the Sumatran Rhino was convened in conjunction with the International Rhino Conference in San Diego. In attendance were representatives of the 4 countries and 8 of 11 facilities maintaining captive specimens.

The purpose of the session was to review and advance the captive propagation program as part of the conservation strategy and action plan for this species. Studbook Keeper Foose presented a summary of the program since 1984:

- 31 (12/19) rhino have been captured in the 3 regions where rescue operations are being conducted: Indonesia 15 (6/9); Peninsular Malaysia 11 (2/9); Sabah 5 (4/1).
- 9 (4/5) rhino have died from a variety of causes which were reviewed; mortality has been differential in the various regions and facilities; death rates have declined over history of the program; last death occurred in 1989.
- One animal has been born in captivity although conceived in the wild.
- 23 (8/15) rhino are alive in captivity today in 5 countries and 11 facilities: Indonesia 7 (3/4) rhino at 4 sites; Peninsular Malaysia 7 rhino (1/6) at 2 sites; Sabah 3 (2/1) rhino at 1 site; U.K. 2 rhino (1/1) at 1 site; U.S. 4 (1/3) rhino at 3 sites.
- Reproduction has been impeded by dearth of mature males.

An institution by institution and animal by animal review of the captive population was conducted. Representatives of the 3 regions described their plans to optimize reproductive opportunities for rhino. Breeding activity was described in the U.K. and Jakarta where apparently full copulations have been observed. Plans were discussed to place male with females on regular basis in new Sungai Dusun Rhino facility in Peninsular Malaysia which will also now resume attempts to capture additional rhino especially males. U.S. representatives discussed plans to place all 3 females with male over next year.

Parties agreed to intensify efforts to investigate subspecies distinctions among rhino from different regions to guide reproductive programs. Amato offered his laboratory without qualification for this effort. A research working group was also organized to facilitate and improve cooperation and coordination among scientists in the several countries.

Finally, a prototype proposal to employ the species as an umbrella and perhaps Heritage Species was presented.

Parties agreed to continue dialogue and collaborations at October Rhino Workshop in Indonesia.

AGREEMENT FOR A COOPERATIVE PROJECT

BETWEEN

THE DIRECTORATE GENERAL
OF
FOREST PROTECTION AND NATURE CONSERVATION
OF THE MINISTRY OF FORESTRY
OF THE REPUBLIC OF INDONESIA

AND

THE SUMATRAN RHINO TRUST OF THE AMERICAN ASSOCIATION OF ZOOLOGICAL PARKS AND AQUARIUMS

FOR CONSERVATION OF
THE SUMATRAN RHINO

ARTICLE I
BACKGROUND

1. This Agreement is entered into the date set out at the end of this Agreement by:

   (a) The Directorate General of Forest Protection and Nature Conservation (PHPA) and

   (b) the AAZPA Sumatran Rhino Trust (SRT)

2. The purpose of this Agreement (signed on June 16th, 1987) is to continue the Conservation project between the parties as part of a global strategy for conservation of the Sumatran Rhinoceros (*Dicerorhinus sumatrensis*) referred to as the "Rhino".

3. The goal of the strategy is the long-term survival of the Rhino as a species and also as a component of its natural ecosystem.

4. The strategy is justified because:

(a) The Rhino is a greatly endangered species;

(b) The Rhino presently survives in the wild to a great extent in small, isolated populations which may not be genetically or demographically viable for the long term;

(c) The Rhino population is decreasing due to poaching, habitat destruction and a combination of factors;

(d) Elimination of this species will deprive mankind of an irreplaceable, natural resource;

(e) The purpose of this Agreement is implementing a conservation program to prevent the extinction of the Sumatran Rhino and thereby enrich our environment by preserving for mankind a species of invaluable, scientific, educational, and cultural significance.

5. The strategy is attempting this goal through programs both for:

(a) The protection of viable population in sufficiently large areas of natural habitat, and

(b) Captive propagation to preserve a reservoir of genetic diversity employing animals with no apparent hope *in situ* of contributing to the long-term survival of the species. Such animals will be referred to as "doomed".

6. The expertise and resources of the SRT are largely oriented toward captive propagation. However, their contributions will also support *in situ* conservation efforts.

7. The primary purpose of the captive propagation is to reinforce the long-term survival of Rhino in the wild.

8. While the major contributions of the SRT should and must be oriented to the captive propagation components of the conservation strategy for the Rhino, such as supports the Rhino Captive Breeding Management Plan in Indonesia. The other cooperative nature of the Agreement will provide technical support from the SRT to Indonesia for the *in situ* conservation efforts.

This financial and technical support includes :

(a) Assistance from the SRT to increase protection of viable natural population and sanctuaries. Priority in this regard will be accorded to the National Parks in Sumatra containing viable Rhino populations.

(b) Surveys to determine which Rhinos are considered doomed.

(c) Training for Indonesians in management of captive and wild populations.

(d) Transfer of capture, transport and wildlife husbandry technology.

ARTICLE II
SPECIFICS OF THE PROJECT

1. Captive propagation programs are under development in Indonesia and America.

2. Field operations to collect appropriate Rhinos will continue in Indonesia. Two SRT Representatives are coordinating and facilitating these efforts ; A Field Director (Mr. David Anthony Parkinson) and an Executive Director (Mr. Francesco Nardelli).

3 Because of the long distances and the local necessities of the project, the Field Director represents the SRT on day-to-day capture team, the constructions of the holding pens, the transportation and management of the animals after capture and the basic logistics supporting the operations in the field in Indonesia.

4. The Executive Director is responsible for all liaison between the SRT and PHPA. Funds from the SRT for the project are directed through the Executive Director who is responsible to the Trust and who must present the documentation of costs and a financial statement on a quarterly basis.

5. The field capture team consisting of local personnel, appointed by the SRT and PHPA will continue to operate in Indonesia, under supervision of the regional officers of PHPA. This capture operation will continue until the numbers of rhinos agreed upon are collected. However the contractual obligation for the capture operation will cover 2-years period from the date of signature of the Agreement by all parties. At the end of this 2-years period, signatories to the Agreement will review the project and decide whether it is to be continued, modified or discontinued.

6. The number and identity of "doomed" animals to be captured and areas in Indonesia for capture operations will be determined by the PHPA using as criteria, objective evaluation in each case of the size, quality and security of the habitat and the

long term viability and protectability of the population. The capture team will not be limited to any specific area and may collect at various sites with the approval of the PHPA.

7. All the animals captured in Indonesia and their progeny will be jointly owned by PHPA and SRT. A Rhino Breeding Center will be developed with the assistance of SRT in Indonesia. It is the objective to capture at least 7 potentially breeding pairs of Rhino. Distribution of these pairs of Rhino will be : 2 pairs to remain in captive facilities in Indonesia specified by PHPA; 5 pairs to be placed in SRT facilities in North America. Since it is unlikely that Rhino will be captured in pairs, the order of distribution will be : 1st, 3rd, 4th, 5th and 7th females captured and the 1st, 3rd, 4th, 5th and 7th males captured to SRT facilities in North America; the 2nd and 6th females captured and the 2nd and 6th males captured to Indonesian facilities. In case of death or infertility of any Rhino, they will be replaced if and when animals will become available. If the total number of capturable Rhino is less that 5 pairs, 1 pair will remain in captive facilities in Indonesia and if the total is 6 pairs, 2 pairs will remain in Indonesia.

8. By signing this Agreement it is understood that PHPA agrees promptly to provide the SRT with all documents needed for the legal exportation of these Rhino from Indonesia, immediately upon their capture.

9. Technical assistance provided by the SRT includes qualified animal keepers and veterinarians, curatorial guidance and support, and apprentice training in Indonesia and SRT facilities for qualified Indonesian curators, keepers and veterinarians. In particular, such technical assistance includes :

   (a) Qualified keepers and veterinarians on an as needed basis to be determined by the SRT Directors at the captive facility in Indonesia, after consultation with the Directorate General of PHPA.

   (b) Veterinary support for the actual capture operations, on short notice and as needed basis to be determined by the SRT Directors, after consultation with the Directorate General of PHPA.

   (c) Training in both Indonesia and USA for curators, keepers and veterinarians to be negotiated on mutually agreed upon level.

   (d) Through these various mechanisms, there will also specifically be an attempt to provide information and instruction in various reproductive and other strategy for the Rhino such as the attached Working Plan for the Transfer of Technology.

10. The animals held in captivity, and their progeny are being managed as part of a single global population for maximum genetic pool preservation and reintroduction potential according to the best biological principles established by AAZPA Species Survival Plan (SSP) Program and the Captive Breeding Specialist Group, and in communication with the Asian Rhino Specialist Group. Rhinos may be relocated among the facilities participating in the globally managed population to produce better genetic combinations and reproductive potential in consultation with the Government of the Republic of Indonesia.

11. Progress reports shall be submitted on an annual basis to the SRT, PHPA, the AAZPA Board of Directors, the Asian Rhino specialist Group, the Captive Breeding Specialist Group, and the United States of America Department of Interior (U.S.A.) CITES Authority.

12. The SRT will donate the sum of US$60,000 per Rhino received in SRT facilities in North America to the Indonesian Rhino Foundation (IRF) to assist conservation projects in Indonesia.

13. The SRT will insure the Rhino captured in Indonesia in such a way that in the event of a death during the transport from the forest to the zoos and for a period of one year, beginning from the date of departure from the base camp, indemnity of US$25,000 per Rhino will be paid to IRF. In the event of a death during the capture, an indemnity of US$5,000 per Rhino will be also paid to IRF. Both parties agree that if four Rhinos die during one calendar year of the Project continuation of the operation will be reevaluated.

14. It is understood that all expenses for the survey, capture and transport of the Rhino will be covered by SRT. All the equipment, vehicles, radios etc. used during the operation will become property of PHPA upon termination of the project.

15 The SRT will actively support IRF, as appropriate, in attempts to attract outside funds from SRT members, AAZPA, cooperations, foundations, organizations and philanthropists to support the conservation strategy for the Rhino in Indonesia both *in situ* and in captivity. Initially, the SRT will contribute $20,000 per year for the duration of this agreement for improving protection and management for Rhinos in National Parks through mutually agreed upon projects.

16. Progeny produced in North America will remain there and/or at other breeding facilities of the globally managed population as SRT decides until the North American population attains

demographic stability and a genetically effective size of 25. Beyond that time and point, animals will be available for reintroduction in the wild if that is deemed necessary and appropriate after consultation between PHPA and SRT. The number of Rhino that might potentially be returned to Indonesia under these circumstances will at a minimum equal the number originally moved from Indonesia to the North America.

Beyond this number, the repatriation of Rhino may continue as deemed necessary PHPA in consultation with SRT at a rate that does not detract from the self sustaining status of the North American population or global captive population as determined by the SRT's SSP program.

17. This Agreement can be amended only by mutual and unanimous agreement of the parties.

18. It is understood that the signature of the representative of Indonesia to this Agreement obligates his Directorate General of Forest Protection and Nature Conservation of the Ministry of Forestry to the terms of this Agreement. Likewise, the signature of the Chairman of SRT obligates the SRT to the terms of the Agreement.

19. Parties to this Agreement appreciate that the financial and technical support of the SRT is provided in the hope of securing the long-term survival of the Sumatran Rhinoceros as species and as a component of its natural ecosystem. The SRT seeks to contribute to the long-term survival of biological diversity through the captive propagation of species that might otherwise be lost or so greatly reduced in numbers as to be highly vulnerable to extinction. The expertise and support of the SRT is and must be directed primarily toward the fulfillment of this goal through preservation by captive propagation. In fulfilling these goals, the SRT seeks to assist Indonesia in its own attempt to propagate the Sumatran Rhino and to prove such limited support as SRT resources permit to related efforts, as part of the conservation strategy for the Rhino to preserve wild populations where these are judged viable using modern criteria of biological conservation. The SRT applauds and does not seek to reduce, replace or supplant the efforts of the Indonesia government to protect its national wildlife in a state of nature.

20. This Agreement will be maintained as the base for continuing the project until viable groups of Sumatran Rhino are established in captivity in such numbers as are stated paragraph 7 above. The parties further agree that the project will be subject to joint evaluation on an annual basis.

IN CONFIRMATION of their agreement to the amendments to the Agreement dated 16th June, 1987 and IN WITNESS of their agreement to the terms and conditions of this Restated Agreement, the following parties have executed this Restated Agreement in such capacity and on such date as recorded below.

Signed in Jakarta on 8 Nov 1990 in two originals in the English language.

FOR THE MINISTRY OF FORESTRY OF THE REPUBLIC OF INDONESIA,

IR. SUTISNA WARTAPUTRA
Director General
Directorate General of Forest Protection and Nature Conservation of The Ministry of Forestry,
Manggala Wanabakti
Jakarta - Indonesia

FOR THE SUMATRAN RHINO TRUST

DR. JAMES DOHERTY
Chairman
of the Sumatran Rhino Trust of the American Association of Zoological Park and Aquariums, the New York Zoological Society, 185 Street & Southern Boulevard,
Bronx, New York 10460
United States of America

WORKING PLAN FOR THE PROGRAM OF "TRANSFER OF TECHNOLOGY" UNDER THE AGREEMENT BETWEEN PHPA - AAZPA/SRT :

Since all the captured animals will be owned jointly, and to minimize inbreeding, and optimize genetic diversity of future generations,

1. It is recommended that the Sumatran rhino in captivity be managed globally.

2 Under auspices of PHPA and SRT, technological transfer will be done between : Cincinnati Zoo Center for Reproduction of Endangered Wildlife (CREW), San Diego Zoo Center for Reproduction of Endangered Species (CRES) in the USA, and Indonesian Center for Reproduction of Endangered Wildlife (ICREW) at Taman Safari Indonesia, technically supported by the Sumatran Rhino Trust (SRT) during the duration of the next SRT agreement.

3. The known technology of Artificial Insemination (AI) and Embryo Transfer (ET), two methods of propagation will be transferred from USA to Indonesian reproductive biologists, led by Dr. Betsy Dresser and Dr. Linda Prasetyo. The cost of the SRT related reproductive research performed in the USA or in Indonesia by SRT personnel conducted during transfer of this technology will be paid for by the SRT.

4. Selected male rhinos in the USA and Indonesia will be trained for collecting semen, and selected females will be trained for insemination procedures. In order to move ahead as rapidly as possible with reproductive technologies, it is recommended to move the recently captured male to the USA where the scientifically technological infrastructure is already in place. There will also be a free exchange of genetic material (i.e. sperm, eggs, embryos) between USA and Indonesian rhino populations.

5. Therefore it is proposed that the start of the collaboration between the Centers would be for Dr. Prasetyo and another qualified Indonesian colleague to do a 1 - 6 month residency at one or both of the two North American facilities, CREW and CRES. At the recommendation of PHPA, reproductive biologists from the USA would visit Indonesia for the exchange of technical expertise. All expenses for these exchange visits will be paid by the SRT.

6. The results of this research will be published in collaboration with all participants.

7. During training, we suggest to keep the male and female at Ragunan Zoo together for natural breeding. Every effort will be exerted to place unpaired animals into breeding situations.

8. In the case of a rhino death, Dr. Dresser and or Dr. Prasetyo should be informed to take the reproductive organs immediately. Protocols will be developed with each participating institution.

9. It will be greatly appreciated if UK and Malaysian reproductive biologists could join us to manage the Sumatran rhino globally.

Jun w

Poaching of Sumatran rhinoceros

It would be very helpful if you could let us know exactly how many Sumatran rhinos had been poached recently from Bengkulu and West Sumatra. The numbers seem to vary with time. It was originally rumored that up to 12 rhinos may have been poached recently. This, if true, is a great tragedy indeed as rhinos are slow breeders and even the loss of one single animal must be considered a catastrophe. So far reading your information, it appears there is strong evidence for the killing of two Sumatran rhinos. It would be helpful to have the facts on this case thoroughly investigated.

The people who poach are usually poor folk trying to make it rich with one kill. But it is invariably the middleman who makes the most out of rhino poaching by selling the horn, hide and even urine and blood at exorbitant prices. A kilogram of rhino horn may fetch up to US$10,000 on the black market. Throughout their distribution, the three species of Asian rhinos are vulnerable to the twin menace of poaching and habitat loss.

The public must be informed of the plight of these magnificent animals. But this is sometimes difficult when some powerful Western organizations are themselves involved in the capture of the so called "doomed" rhinos for breeding in captivity in Zoos both here and abroad. It would be difficult for an illiterate villager to differentiate between this action by the Zoos and that of ordinary poachers. In fact there is a danger that such capture programs may passively encourage poachers to carry on killing the rhinos. (Imitation is the best form of flattery). Already, about 30 percent of the Sumatran rhinos that were captured have died in captivity without contributing anything to the survival of the species.

What must be done is to strengthen the major Sumatran rhino conservation areas such as Gunung Leuser, Kerinci-Seblat and Barisan-Selatan National Park by improving their protection on the one hand and to improve the quality of life of those people who live along the periphery of these reserves. The people living near conservation areas must derive some benefit if these areas are to achieve their conservation objectives. In the absence of such a conservation philosophy, protected areas as viable self-sustaining oases could prove to be poor bets for the long term given the demographic trend in Indonesia. At the current rate of increase, the human population may double to 400 million in 30 to 40 years' time. Aspirations to enhanced standards of living can often cause greater pressure on conservation areas than sheer growth of human numbers.

Although animal populations are more vulnerable to a manipulation of their habitat than they are to a direct manipulation of their numbers, in the case of the Sumatran rhino, given its discontinuous distribution and small population size, local extinctions can occur if poaching is rampant. IUCN/CBSG on the basis of their Population Viability Analysis (PVA) cautioned that in the case of the Javan rhino, the "removal of one animal every two years is sufficient to prevent population growth and is a threat to survival of this small population". But paradoxically, having said this admirable thing, they go on to recommend the removal of "18-26 animals from the population at Ujung Kulon to establish the captive populations"!

Protection is easier, cheaper and likely to succeed than captive breeding, translocation and other *ex-situ* measures which are difficult, expensive and likely to fail. But protection of conservation areas cannot succeed if these areas are not manned by motivated guards. But motivation can only come about if the activities of the guards are appreciated and encouraged by people at higher levels. The guards are the eyes and ears of the conservation areas. But very often they are poorly paid and badly off. Like the U.S. Marines, their motto appears to be, "We have done so much for so little for so long, we could do anything for nothing forever."

The rhino is one of the natural heritages of Indonesia. It would be a great pity if it were to become extinct through the greed of man. The unnecessary extinction of a species such as the Sumatran rhino (or for that matter the more endangered Javan rhino) in Indonesia will represent a great loss to the human welfare.

DR CHARLES SANTIAPILLAI
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Note:
We are looking into this important matter.

The Editor

Readers' contributions to these columns are welcome. State your name and address.

— Editor

INDONESIAN RHINO CONSERVATION WORKSHOP

BRIEFING BOOK

SECTION 6 - INDIAN RHINO DATA

DEMOGRAPHY AND HABITAT USE BY GREATER ONE-HORNED RHINOCEROS IN NEPAL

ERIC DINERSTEIN,[1] Conservation and Research Center, National Zoological Park, Front Royal, VA 22630
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Abstract: We used a register of photographed individuals to census greater one-horned rhinoceros (*Rhinoceros unicornis*, hereafter rhinoceros) in Royal Chitwan National Park (NP), Nepal, between 1984 and 1988. By April 1988, the population was estimated to be 358–376 individuals as determined by regression analysis. The observed rate of increase for the Sauraha population, an intensively monitored subpopulation in the central and eastern part of Royal Chitwan NP, was 4.8% between 1984 and 1988 and 2.5% between 1975 and 1988. The Sauraha population included 87 adult females and 58 breeding-age males, of which only 28 males were judged to have bred during the study period. Annual calf production averaged 7.6 ± 0.8% ($\bar{x}$ ± SE) between 1984 and 1988. No distinct season of parturition was detected. Predation by tigers (*Panthera tigris*) accounted for 4 of 7 calf mortalities, and all 7 calves that died during the study period were <8 months old. Mean annual mortality within the calf, subadult, and adult age categories was estimated to be 2.8, 2.2, and 2.9%, respectively.

Rhinoceros populations reached maximum densities of 13.3/km^2 in riverine forest-*Saccharum spontaneum* grassland mosaics along the Rapti River. Local densities in areas dominated by *Narenga porphyracorma* and *Themeda arundinacea* grasslands were 1.7–3.2/km^2. Annual monsoon floods were responsible for maintaining prime grazing habitat and high population densities.

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Populations of greater one-horned rhinoceros have declined drastically over the last 400 years as a result of land-clearing and poaching (Blanford 1888). By 1988, only 2 populations contained >80 individuals: Royal Chitwan NP, Nepal, and Kaziranga National Park, Assam, India (Dinerstein and McCracken 1990). The Royal Chitwan population is one of the few that has increased over the last decade.

The purpose of our paper is to (1) describe the demography of a subpopulation containing most of the rhinoceros population within Royal Chitwan NP (the Sauraha population); (2) analyze habitat–density relationships within the Sauraha population; and (3) examine population structure of the entire Royal Chitwan population. To this end, we estimated total population size, sex and age composition, seasonality of births, birth rate, interbirth interval, survivorship, mortality, and population growth rate. We also investigated the relationships between proximity to agriculture, the size of flood plain grasslands, and rhinoceros population densities. Finally, we evaluated the importance of annual monsoon floods as a means of maintaining prime grazing habitat and supporting high population densities of this endangered ungulate.

We thank the Conservation and Research Center, National Zoological Park of the Smithsonian Institution for support and the King Mahendra Trust for Nature Conservation and the Department of National Parks and Wildlife Conservation, His Majesty's Government of Nepal for permission to live and work in the Royal Chitwan NP. In particular, we thank H. R. Mishra, B. N. Upreti, and R. P. Yadav for their help. Financial support from the World Wildlife Fund and the United States Agency for International Development mission in Nepal permitted completion of the 1988 census. E. E. Stevens and J. D. Ballou provided valuable advice on demographic analysis and construction of life tables. W. D. Edge, T. J. Foose, W. A. Laurie, G. F. McCracken, M. L. Shaffer, E. E. Stevens, M. E. Sunquist, and C. M. Wemmer improved the manuscript with their comments.

STUDY AREA

The Royal Chitwan NP is located in the south-central Terai region of Nepal (84°20′E, 27°30′N). Rhinoceros and other large mammals are found in highest densities along the flood plain grasslands and riverine forests bordering the Rapti, Narayani, Reu, Dungre, and Icharni rivers (Fig. 1) (Seidensticker 1976, Mishra 1982, Dinerstein and Wemmer 1988). The most critical habitat is a riverine grassland association dominated by

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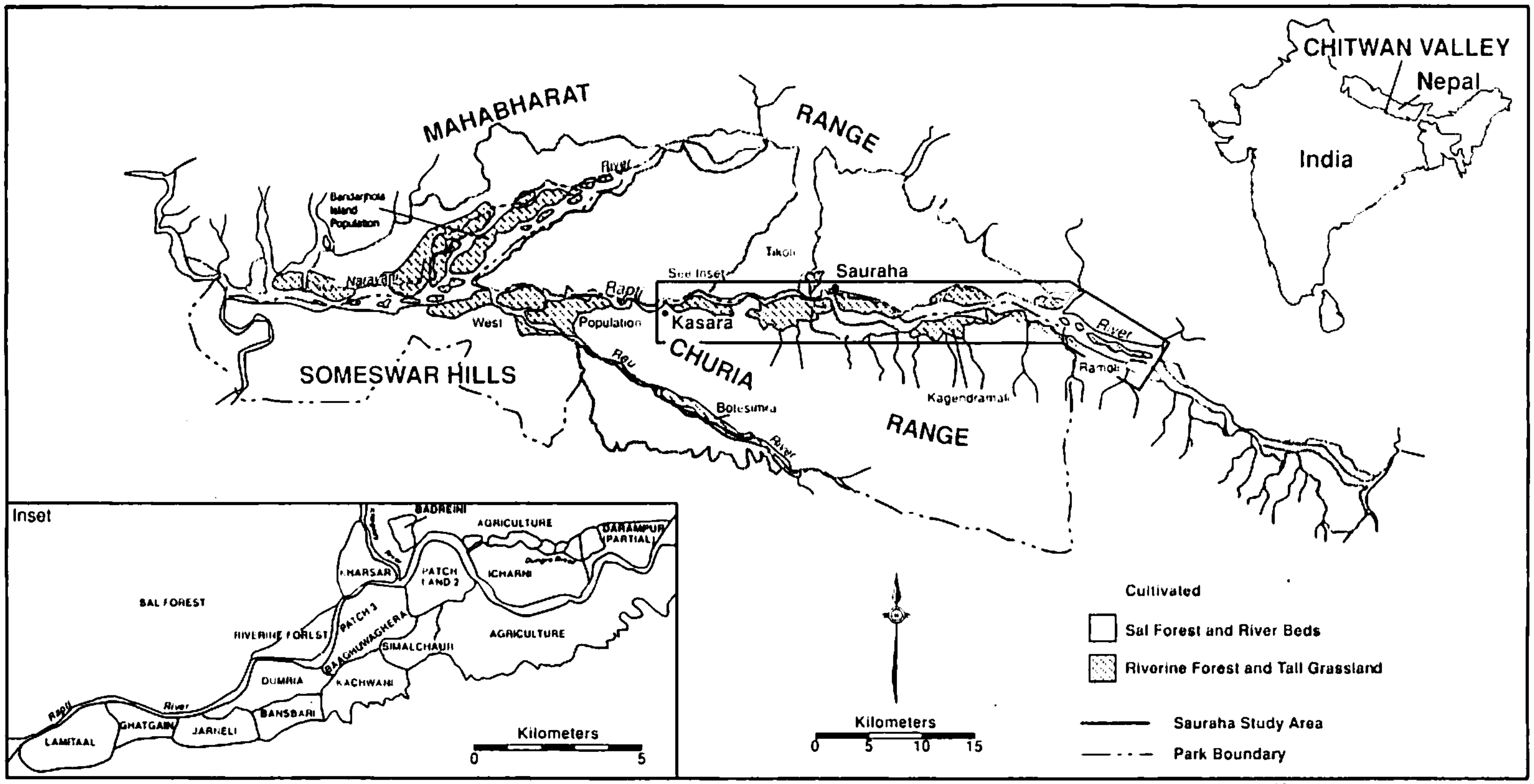

CARTOGRAPHIC SERVICES
University of Maryland Baltimore County

Fig. 1. Royal Chitwan National Park, Nepal, and environs showing major features and location of the 4 subpopulations (Sauraha, West, Bandarjhola-Narayani, and South [Botesimra]) discussed in the text. Inset of the Sauraha area shows blocks searched for greater one-horned rhinoceros (excluding part of Darampur block).