use the captive population to supplement work being conducted in the field. Captive studies would therefore include work on rhino behavior, infant development, reproduction, genetics, physiology, and health. Each topic area will be considered separately:

A. Veterinary research:

(1) Collection of baseline data on pathology and physiological norms is strongly encouraged. An autopsy should be performed to determine the cause of death. At this time, the following tissue samples (2-4 cm in size) should be collected and stored in formalin: liver, kidney, spleen, and whole reproductive tracts (male and female) and eyes.

B. Behavioral research:

(1) A minimum of 1 personnel (keeper) should spend 1 hour/day observing and recording the behavior of captive animals. The following behaviors should be recorded on a continuous basis: vocalization, urine spraying, chasing, aggression (pushing, shoving, slashing with lower canine) and mounting. The data should be collected at the same time daily (e.g. 8-9 AM). Each time a behavior occurs, the time (to the closest minute) and identity of the animal exhibiting the behavior should be recorded. The date and amount of time the animals were observed should also be recorded. It would also be useful to record the ambient temperature and weather conditions (sunny, raining, etc.). Descriptive notes should be taken on any new or unusual behaviors. Each data sheet should also note whether a pair was together or apart.

C. Nutritional research:

(1) Institutions holding Sumatran rhinos are encouraged to collaborate with Dr. Ellen Dierenfeld at New York Zoological Society on the further analysis and development of diets.

(2) Whenever possible, blood should be collected for analysis of Vitamin E levels.

D. Reproductive research:

(1) Research should be conducted to document the reproductive physiology of the Sumatran rhino.

(2) Collection, evaluation and storage of semen should be carried out collaboratively between the Surabaya Zoo and the Faculty of Veterinary Medicine, Bogor Agricultural

University or by any facility involved with reproductive studies.

(3) Institutions holding Sumatran rhinos should collaborate with Dr. Nancy Czekala (San Diego Zoo) and Dr. Ellen Shaw (London Zoological Society)in their studies of hormone metabolites in urine samples.

(4) Of interest is the use of feces to determine the sex of Sumatran rhinos. The ability to differentiate between males and females in captivity through fecal analysis could be extremely helpful to those working with this species in the field.

E. Genetic research:

(1) Ongoing and proposed research on taxonomic issues should continue. Resoluation ofsubspecies questions is a high priority and has important implications for the development of a global management plan for the Sumatran rhino.

(2) In a case of an autopsy, the following tissue samples (2-4 cm in size) should be collected and frozen for genetic analysis: liver, kidney, spleen.

(3) Hair samples should also be collected, sealed in plastic bags and stored at room temperature (i.e., if a freezer is not available.

F. Other

(1) Field workers have identified a need to record foot print patterns of animals and how they change with age. Such information could be used to aid census efforts in the wild.

(2) Captive animals should also be used to work out additional technological and practical problems facing field researchers. For example, there is a need to develop a method to attach radio-telemetry equipment to Sumatran and Javan rhinos. Captive Sumatran rhinos should be used to help develop this technology.

VII. STANDARDIZED DAILY REPORTS:

(1) All holding institutions should mantain standardized daily reports on each of their animals. Such reports should include the following information:

(a) types and amount of food fed

(b) types and amount of food eaten

(c) feces - condition, amount and number of defecations/day

(d) significant behavioral changes - vocalization, spraying, pacing, aggression, lethargy, etc.

(e) weather condition, ambient temperature and relative humidity

(f) identity of person preparing the report.

(g) date of report.

(h) physical condition of each animal (injuries, skin condition, foot condition, etc.)

(i) veterinary diagnosis and treatment, including administration of drugs and dosages.

(j) any important events related to management (e.g., movement of animals between enclosures, pairings, changes in diet, etc.).

(2) Daily reports should be sent to all personnel with primary responsibility for the welfare of the animals (e.g. curators, veterinarians, directors).

(3) A logbook containing duplicates of the daily reports should be kept at the rhino enclosure (e.g. in the keeper's area).

VIII. ANNUAL REPORT

(1) Each institution holding Sumatran rhinos should submit an annual report to the International Studbook Keeper no later than 1 June of each year (Dr.Tom Foose, CBSG, 12101 Johnny Cake Ridge Road, Apple Valley, MN 55124 USA; FAX: (612) 432-2757). The reports will be published with the studbook. The reports should include the following information:

(a) any changes in the composition of the collection (e.g., births, deaths, acquisitions, removals).

(b) descriptions of ongoing research, if needed.

(c) any progress in meeting the recommendations agreed upon by the management committee (see above).

(d) veterinary matters (diseases encountered, treatments, etc.)

(e) listing of publications, if any.

The first annual report should include a description of current facilities, collections, management protocols, etc.

GROUP 3: REVIEW OF THE SUMATRAN RHINO EX-SITU AND HUSBANDRY PROGRAM

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PROTOCOL FOR MONITORING SURVEY AND PROTECTING SUMATRAN POPULATIONS, AND CONTROLLING TRADE IN THEIR PRODUCT

Chairmen	N J van Strien	- SSC Asian Rhino Specialist Group
	D. Setijono	- Lampung Province Regional Office, Dep. of Forestry
Participants	C. Schurmann	- Netherlands Min. of Agric. Nature Con. & Fish
	H. Napitulu	- Sub. BKSDA Sumatra Utara Medan
	P.L. Wells	- Sumatran Rhino Survey
	Susilo Legowo	- Sub BKSDA Bengkulu
	R. Bintoro	- PHPA Aceh Province
	A. Badrudin	- PHPA Riau Regional Office
	Mohd. T. Abdullah	- Wildlife Management, DWNP, Malaysia
	W. Isnan	- PHPA Barisan Selatan N.P.
	A. Hartadi	- PHPA Gunung Leuser
	D. Rufendi	- WWF Kerinci Seblat N.P.

SCOPE

This proposal examines the proposal developed by the PHPA for the implementation of the Indonesian Sumatran Rhino Action Plan. With particular reference to the in-situ conservation action and the organisation chart for the Indonesian Rhino Protection Mobile Unit. For the continued survival of the Sumatran rhino in the wild, protection from poaching is utmost importance. This can only be achieved by continued presence in the field of dedicated rhino monitoring and anti-poaching teams in particular in the major rhino areas; Bukit Barisan Selatan N.P., Kerinci Seblat N.P., and the Gunung Leuser N.P.

Two mobile units will be formed to work in other rhino areas and to support and guide the field teams in the National Parks. These mobile units will conduct surveys, train the rhino monitoring and antipoaching units, conduct more specific research programmes and will coordinate to local activities. The whole operation will be guided by a Rhino desk officer, who will coordinate all operations, liaise with other departments and provide guidelines for the various field activities.

RHINO MONITORING AND ANTI- POACHING TEAMS

TASK

To prevent poaching and to monitor rhino populations in key areas of the rhino population. In some areas emphasis will be primarily in poaching prevention, anti-poaching units, and in other areas on monitoring, monitoring units. The teams must be flexible in undertaking the tasks assigned. Other activities will be carried out for the proper management of the resource.

POACHING PREVENTION

The methods employed in poaching prevention are primarily field patrols to look for traps and destroy traps, look for other signs of poachers and to gather evidence to identify the people involved.

The patrols will be required to develop good relations with local people , obtain information and assistance in the prevention of poaching, and to increase awareness of the rhino. They should also try to establish the identity of contact persons and the routes used for the horn trade, and relay such information to the appropriate authorities.

RHINO POPULATION MONITORING

Population estimates based on appropriate and consistent field techniques including: track counts, sighting counts, dropping etc counts, and the utilisation of wallows and saltlicks. Detailed procedures for all these techniques should be worked out and developed by the staff of the rhino unit desk officer. This should be documented in a standard field guide. The members of team will receive on the job training form the mobile team units and the rhino desk officer.

QUALIFICATION OF PERSONNEL

The people selected for the anti-poaching and monitoring units should be recruited in part from people in the locality of the key areas. All members should have considerable knowledge of the rain forest but in each team one person should have power to apprehend poachers. Each team should consist of four to five people one of which should a team leader with appropriate rank and skills.

EQUIPMENT REQUIREMENTS

All the teams will require to be well equipped for field work. The standard equipment will be:

Tents
Compass
Short range radios
Maps
Rucksacks
Firearms if required
uniforms
etc

REQUIREMENTS OF KEY AREAS

Bukit Barisan Selatan N.P.

Situation

The current major threats are of habitat loss through encroachment. Poaching is presently a lesser threat. Surveys and monitoring units will provide sufficient protection at this present time.

Staffing levels are adequate but access to large parts of the park is difficult.

Requirements

One monitoring unit initially should be established. The establishment of further units will be decided upon based on the observations of the founder unit.

Special equipment that will be required are:

4-5 Horses
3 Motor bikes
1 Seaworthy boat
2 Perahu with outboards

KERINCI SEBLAT N.P.

SITUATION

There is information that indicates there is serious poaching within and on the areas adjacent to the park. Currently the park is understaffed and new teams will have to be recruited.

Requirements

Initially one monitoring team will be established based in Sungai Penuh to cover the central rhino area. Two anti poaching units, one in Bengkulu and one in the Kerinci area. It is expected that a further two teams will be added within two years and possibly two more later.

Equipment

3 Four W. Drive
3 Motorbikes
3 Guard posts with radio communications.
Additional Shelters close to areas vulnerable.

GUNUNG LEUSER N.P.

Situation

Currently the levels of poaching are high and may threaten the viability of this population. The current staffing levels are such that additional staff will have to be recruited.

Requirements

Three antipoaching teams should be established immediately. The areas that should be covered by each group are: Mamas/Kompas, Kapi area, and the Sikundur/ Langkat.

Equipment

2 4 WD Vehicles with radio communications
3 Motor bikes
1 Motor boat for lower Alas river.

KALIMANTAN

A survey should be carried out to establish status of the rhino population. We would recommend that there is a provision in the future for a permanent survey team and protection. If there were any firm indications of their existence then the teams should be immediately put in place.

MOBILE UNITS

Functions

1. Training and technical support to parks unit.
2. Supervision of park units.
3. Providing advice on and assistance with special operations like translocation, research programmes etc.
4. Law enforcement, especially in connection with rhino poaching activities.
5. Surveying and evaluation of new areas.
6. Reporting direct to Rhino desk officer and regional offices.
7. Coordinate their activities with local authorities.

QUALIFICATIONS OF PERSONNEL

The team should be composed of experienced persons, whose combined experiences and skills allow the team to do the tasks specified. Especially important are a wildlife or nature conservation background, research experience, administrative experience, leadership. Ideally a team should be composed of an experienced teamleader with a nature conservation background, a wildlife ecologist, a person with an administrative or legal background.

EQUIPMENT

One 4 WD vehicle per team, equipped with a powerful radio to communicate with the regional offices.
Office space, preferably in the same building as the monitoring units of Gunung Leuser and Kerichi Seblat.
2 Lap top computers with printer.

LOCATION OF MOBILE UNIT

One unit should be established to serve the central and southern parts of sumatra, including Kerinchi Seblat and Bukit Barisan Selatan. This unit should have its home base in Sungai Penuh.
The second mobile unit should be established to serve the northern part of Sumatra, including Gunung Leuser. This unit should have its home base in Medan.

THE DESK OFFICER

The desk officer should be a very experienced person with a strong background in nature conservation or wildlife ecology. His rank should be director or equivalent. This should be a permanent post an continuity should be maintained were possible. He should report directly to the Director General PHPA and should coordinate his activities with the other directorates and other agencies involved in the rhino conservation activities.
Considering the complexity of the task the desk officer should have two assistants, and sufficient secretarial support. One of the assistants should have a scientific background the other and administrative background.
One of the tasks of the desk office should be to design protocols and standard operational procedures for the various tasks of the mobile and monitoring and antipoaching units.

EQUIPMENT and STAFF SUPPORT

Full office and secretarial support.
Sufficient provisions for frequent field visits.

EXTERNAL TECHNICAL SUPPORT

Especially in the initial phase of the development of the rhino units external technical support could be useful for the training of the units and for the development of the scientific and monitoring programmes.
The exchange of officers and team members between the Malaysian and Indonesian Rhino Protection Group is highly recommended.

CONSERVATION STRATEGY FOR THE SUMATRAN RHINO
Working Group
4 October 1991

Present:

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Cathy MacKinnon, WWF-Indonesia, Bogor, Indonesia

Background. The task of the working group was to review the Indonesian Rhino Conservation Strategy, in particular as it relates to the Sumatran rhino. Three other documents were drawn upon in our deliberations: the Heritage Species Conservation Action Plan for the Sumatran rhino, the CBSG PVA report, and the SSC Asian Rhinoceros Action Plan. The working group endorses the intention and content of the document, and offers the following comments and recommendations for the Sumatran rhino.

Three Goals of the Indonesian Sumatran Rhino Strategy

1. Sustain several large wild populations for long term survival of the species.
2. Acquire the knowledge necessary to sustain viable wild populations.
3. Re-establish populations of the Sumatran rhino within its previous range.

Objectives:

1. Concentrate protection and management for large wild populations on:

Kerinci Seblat National Park (Sumatra)
Gunung Leuser National Park (Sumatra)
Barisan Selatan National Park (Sumatra)

Kayang Mentarang and Ulu Sembakung (Kalimantan) (if surveys prove existence of the rhino)

2. Gazette as National Parks with well defined boundaries the 4 major rhino areas and possible receiving sites as soon as possible.

Gunung Leuser N.P.
Kerinci Seblat
Barisan Selatan
Kutai National Park

3. Develop and implement policies of integrated conservation and development in and around all National Parks.

4. Besides its major role in development, planning, and management of protected areas, PHPA should also accept joint responsibility for regulation of buffer zone activities and land use around protected areas.

5. Incorporate 3 kinds of conservation sites into the strategy and evaluate their success in achieving rhino conservation objectives, as follows:

Protected Areas:

<u>Objective</u>: Maintenance and restoration of viable wild populations of Sumatran rhinos and the environmental conditions to which they are adapted.
<u>Operation</u>: Minimal management intervention, annual census desired, area is secured and protected. The goal is a self-sustaining population of wild animals.
<u>Population</u>: 1500+ animals in 4 Indonesian sites

Rhino Sanctuaries:

<u>Objective:</u> A natural or artificially enclosed area within a protected area stocked at a population level which does not seriously degrade the habitat; by definition such a sanctuary does not allow immigration or dispersal. The specific goal of rhino sanctuaries is the production of stock for reintroduction to protected areas. As an innovation of captive management, the method is untested and will require detailed planning to minimize the impacts of confinement on the behavior of animals born under these conditions.
<u>Operation</u>: The rhino population is managed by a resident staff, the goal being minimal impact of the animals on the habitat and minimal requirements for husbandry and intervention, such as supplemental feeding.
<u>Population</u>: 150 animals total is targeted for 3 sites (50 each); the initial founding population goal will be 10 animals per area.

Zoos:

Objective: Populations contained in small intensively managed areas, where daily maintenance and [illegible] is provided. The specific goals of zoo populations are captive breeding, which through proper genetic and demographic management may generate stock for reintroduction. Research and public education are equally important goals.

Operation: Intensive daily management with full time staffing of animal caretakers, biologist and veterinarian.

Population: an ultimate global population of 150 animals derived from 18-20 founders, 14 of which are already in captivity.

- Recommended objectives for each kind of conservation area:

	# Sites	Ultimate Pop.	Initial Pop.
Large Wild Areas	4+	1500+	Existing
Wild Sanctuaries	3	150	10 each (30 total)
Captivity	Indonesia & Elsewhere	150	18-20

6. Develop the Rhino Conservation Unit as Delineated in the Indonesian Rhino Conservation Strategy, but with the insertion of more detail on resident protection and management units as discussed in the Heritage Species Prototype.

7. Encourage development of the Board of Councillors of the Indonesian Rhino Foundation as a mechanism for providing input for further development of the strategy.

Recommended Priority Actions:

1. Strengthen protection and management of Sumatran rhino reserves including provision of additional manpower and other resources;

2. Conduct coordinated surveys in Kalimantan and East Malaysia to determine where and approximately how many rhinos exist in the wild;

3. Determine the taxonomic status of rhinos originating from Kalimantan, Sumatra and Malaysia, as all decisions regarding genetic management and reintroduction will be affected by genetic relationship.

4. The number of animals removed from isolated populations in the wild for captive breeding will be limited to 18-20 animals. Every effort should be made to acquire these animals in the near future to avoid disparities in age and

sex ratio.

	Males	Females	Total
Total Goal	8	10-12	18-20
In Captivity	5	9	14
To Be Captured	3	1-3	4-6

5. Animals which are captured from isolated populations and which exceed the captive founder objectives will be used to re-establish populations within protected areas as part of an intensively managed recovery program.

Discussion

The recommended populations and the points of agreement from the 1989 Indonesian Rhino Workshop are realistic. Discrepancies in these recommended populations from what appears in the Asian Rhino Action Plan and the Heritage Species Prototype are due to summation of populations in East Malaysia and Kalimantan (i.e., the island of Borneo). The recommended objectives are for 1000 rhinos in Sumatra and 500 in Kalimantan, with three populations in Sumatra of 100 animals or more, and one large population in Kalimantan.

Recovery of the species through restocking will be attempted in:

a) Kutai Reserve, Kalimantan; translocation from small isolated populations in Kalimantan is the preferred method.

b) a contiguous area in Sumatra consisting of Bukit Rimbang Baling, now a game reserve in Riau, proposed as a wildlife reserve (about 1,360 sq km), and a protection forest area, West Sumatra/Riau Boundary, 1400 sq km, a protection forest.
c) Mahato-Kumu, Protection Forest, Riau, 3500 sq km, where a an Intensively Managed Wild Rhino Sanctuary has been proposed (The area was trapped for the Howletts rhinos, but animals still survived there when the project was shut down).

6. Research Priorities

The working group affirms that scientific research is an essential ingredient in the conservation of endangered species, bio-diversity, and protected areas. Detailed investigations on the ecology and behavior of the Sumatran rhino are considered essential to the long term conservation and management of the species. In this connection, it is recommended that:

a) a workshop be convened to identify field and captive research priorities, especially ecology and behavior, relevant to Sumatran rhino conservation;

b) a continuous monitoring program for Sumatran rhinos be initiated in all reserves;

c) training of field personnel, and the development of reliable censusing methodology be undertaken.

N Stanley Price.

(6)

Report of Working Group 6 : Re-introduction, ~~and~~ Translocation and Capture Protocols of Rhinos

Chairman: M. Stanley Price

1. Feasibility Study

Release area requirement

(1) Historic range of species, preferably

(2) size :should be large enough for minimum 100 animals carrying capacity, with assumed 15 sq. km per rhino of exlusive area, but could accept establishment of small numbers of translocated animals and interests of testing ~~mamanegemat~~ methods, in an area ~~of no~~ where no MVP is possible. However, this small area management approach may lead to problems of animals wondering out.

(3) Flora meeting diet requirements

(4) Assesement of area as suitable habitat: NB Ujung Kulon may not be typical of historic Javan range.

(5) Carrying capacity estimates for area.

(6) Adequate water, wallows, minerals

(7) Low human densities adjacent to release area

(8) Assesement of predation risk on young

(9) Status of reintroduction area. For Javan, minimum is national park or preferably nature reserve

(10) Integrity of release area: absence of livestock, and to ~~the~~ avoid disease transmission, no hunting, logging, firewood collection.

(11) Security of area must reach pre-determined levels before any deliberate capture starts or any isolated animal moved there.

(12) Extension efforts with ~~and~~ local communities must be well established, with reintroduction project providing employment as possible.

(13) Assesment of threats to conservation use of release area through eg. ~~ce~~. loss of habitat to forestry, pollution from outside etc.

(14) Release site must have good communication and access.

2. Conservation Strategies

Assume for both Sumatran and Javan that 3.7 animals would be minimal.

(a) Sumatera:

1. SRT catching proceeds until 4 male commitment for USA is met

2. Any two females caught go to reinforce existing secure population through release from pen into wild directly

3. After SRT commitments, all male and female reinforce, until new population site is identified, feasibility study is done and pre-requirements met

4. When release facility ready, with 3.7 as target, priority goes to animals for new population, others reinforce existing population

(b) Javan :

1. Catching effort in Ujung Kulon is directed to 3.7

2. Individuals in excess of 3 males or 7 females are released, following exhaustive taking of samples and fitting radiocollars.

3. Management for Release

All rhinos, irrespective of origin, type and size of movement and destination will be held in a pen at the release site. This is to allow (1) recovery from travel, (2) development of site fidelity.

Each will then be released singly into a "5-acre" enclosure, bounded by solar electric fence, with cut line kept clear. This will allow rhino to feed to some extent on natural vegetation and be monitored closely.

As some stage after release from enclosure, all installations can be removed and used new site.

Rhino will move through pen and enclosure singly, and with only one release at each site. The aim is to develop a patchwork of well-spaced animals with release area attachment.

Any captive bred rhino returning to Indonesia will follow the same procedures, hopefully using great experience in Indonesia by they. Management will be modified as necessary, but much more detailed protocols and learning prcesses necessary. The likely time scale allows no greater specification. Good communications between each field site and part/project headquarters is essential.

4. Capture Methods

Very few options, as immobilization is not feasible for either species. Animal must catch itself, either by surface trap or pit. Latter prefered for Sumatran very highly strung on capture, but tames within 12 hours.

Ujung Kulon photo-trapping is seen potentially to allow very selective trapping for ~~derived~~ sex/age. This in contrast to Sumatran which in disturbed habitat may use a trail once a year. In undisturbed habitat, a Sumatran patrols each path every 4-5 weeks, a common capture time.

5. Monitoring

An essential component of any translocation. A part colleting data, useful to allow intervention so that acclimatization and release are as soft as possible. This is important for small rhinos of endangered species.

Here is a basic list attributes to be monitor both pre-and post-release.

(1) Location, every released animal must be radio-collared
(2) Feeding observations
(3) Sexual/reproductive activity
(4) Behavioural interactions/social behaviour
(5) Ranging behaviour
(6) Condition and health by visual observation
(7) Use of habitat

Monitoring will require at each release area full-time researchers, who pre-trained and experienced.

6.Timing and Scheduling

Given the realities of forest habitat dynamics on Sumatra following sequence must start as soon as possible:

A. Javan : (1) Decide to establish second population
(2) Identify location of release area
(3) Do feasibility study
(4) Implement pre-requisites identified in feasibility.
(5) Schedule capture to start according to number (4)

Goal: In 3 years have pre-requisites implemented, hence be ready to translocate

B. Sumatran: (1) Continue with SRT trapping
(2) Identify areas to reinforce populations, using release area criteria as far as possible, then build facilities
(3) Identify priority area for ~~near~~ new population, to same criteria as above.

7. Duration

Hard to be precise but can specify:

Phase I: High intensity management, monitoring and security: this will last until the first calves are conceived and born in ~~near~~ new location. Estimated duration 4 years.

Phase II: Will follow from phase I and will last until the first calves are born to animals themselves born at the new location. ie these will be the first calves to grow up learning from forest-born mothers. Estimated duration 6 ←———— years

8. Staffing and Management

A number of key skills will be needed on site:

(1) Experienced ~~and~~ in rhino husbandry, including veterinary aspects
(2) Good security: hand-picked and armed guards
(3) Researchers trained in radio-tracking ~~for field manager in charge of all aspects~~.
(4) Field manager in charge of all aspects

At headquarters, a Rhino Management Committee should be created to meet frequently and solve problems etc. It should include someone from the Indonesia Rhino Conservation Trust, and some outside expert and technical advice.

9. Financing and Costing

Translocations and establishment of new populations will be over and above normal government funding, and in addition to Effendi's proposals.

Joint Priorities:

(1) Site identification and development for releasing isolated Sumatran rhinos through reinforcement.
(2) Javan Rhino translocation

Goal: First project designs and cost estimates within 6 months. Outside consultant may be needed to meet this schedule.

(3) Lesser priority, establishment of new population(s) for Sumatran.

9 a

Participants in Working Group 6 , 4 Oct 1991

No.	Name	Position
1.	John B. Sale	UN Advisor, Sabah Wildlife Depart
2.	Sutresna Wartaputra	Sub balai KSDA Sumatera Selatan
3.	Ruswendi	Sub balai KSDA Jambi
4.	A. Faizal Rusdy	Partisipan/PHPA
5.	Deswan Putra	Kanwil Dephut Jambi
6.	Nur Mua'rif	Kanwil Dephut Sumbar
7.	Henny Setiawan	Secretary of Sumatran Rhino Trust
8.	Endah Wahyudi	Kebun Binatang Surabaya
9.	Sukianto Lusli	Sumatran Rhino Trust
10.	Mark Stanley Price	African Wildlife Foundation SSC Reintroduction Group
11.	Tony Parkinson	Field Director, Sumatran Rhino Trust
12.	Mahedi Andau	Director -Wildlife Dept, Sabah Malaysia

WORKING GROUP ON TRANSLOCATION AND RE-INTRODUCTION

SOURCES	ROUTES		DESTINATIONS
WILD SOURCES SELECT INDIVIDUALS FROM INTACT WILD POPULATION OR RANDOMLY COLLECTED :SOLATED "DOOMED" INDIVIDUALS	DIRECT TRANSLOCATION OF WILD INDIVIDUALS	⟹	**VIABLE WILD POPULATION** **VIABLE SECURE HABITAT** **OUTSIDE SPECIES RANGE** EITHER WITH EXISTING STOCK ------> RE-INFORCEMENT
	CAPTIVE OR SEMI-CAPTIVE BREEDING PROGRAMME TRANSFER OF TAME CAPTIVE BREED OFFSPRING OF CAPTIVE ADULTS	⟹	OR NO EXISTING STOCK ------> RE-INTRODUCTION
CAPTIVE SOURCES **"SURPLUS" ANIMALS FROM** **LONG ESTABLISHED CAPTURE GROUP**	TRANSFER TO WILD	⟹	**OUTSIDE SPECIES RANGE** NO EXISTING STOCK ------> INTRODUCTION

Report and Recommendations of the Working Group for Community Relations and Communications
Workshop on Indonesian Rhino Conservation
Bogor, Indonesia
4 October 1991

Group 7

Participants

Chair: Mr. Steve Hage, Minnesota Zoo
Co-chair: Mr. Dwi R. Muhtaman, Indonesian Tropical Institute
Mr. Arif Aliadi, Indonesian Tropical Institute
Mr. Darryl Miller, Perth Zoo
Mr. Hari Jonathan, FMPIA Biology, University Pakuan, Bogor
Mr. T. Syamsulhad, Taman Safari
Mr. A. Heru Maryadi, Taman Safari
Mr. Vince Deschamps, WWF Ujung Kulon
Mr. Zainal Makmur, Direktorat Panyulatian, KSDA
Dr. Russell Betts, WWF Indonesia
Mr. Mal Clarbrough, New Zealand Project in Ujung Kulon
Dr. Niels Halbertsma, NWF

List of Proceedings

1. Inventory
2. Discussion
3. Action/commitment

Overview

The problems of rhinoceros conservation are fundamentally social and economic ones. Biological problems have arisen as a consequence of them. The development and implementation of biological solutions is dependent upon a favorable social and economic environment. Creation of this environment through education and community support should be the basic objective of Indonesia's efforts to develop public awareness of rhinoceros conservation.

The central component of the strategy required to achieve this objective is the development, resourcing, and implementation of programs of community-based conservation and economic development. No environment that is not valued and of value to the communities around it can survive. Local communities have traditionally relied on the resources of the forest. These linkages need to be maintained and new ones created. Local communities must be given priority for employment in park activities and must have a significant role in development of policies and park management. They need to be provided with the information and training needed to take up these opportunities. Training of extension officers needs to provide them with skills in the fields of communication, economics, social work, and conservation to enable them to provide this training.

The resources, materials, and human resources required to undertake these programs can only be provided by a nation committed to conservation of its natural heritage. Development of public awareness and concern for rhinos and conservation in general is essential. The media, schools, non-governmental organizations, museums, zoos, and promotional campaigns provide opportunities to reach the general community. Information also needs to be specifically prepared and directed at industry, politicians, and civil servants to ensure that monetary resources are made available.

The international community has the resources and expertise to assist Indonesia to implement these strategies. Community-based conservation and development should be included in Indonesia's requests for international aid, and needs to be supported by the international community.

<u>Needs Assessment</u>

During the initial discussion, the working group was able to identify a list of concerns/situations that would benefit from improved community relation programs. They are as follows:

target problems
- poaching (demand for rhino by-products).
- deforestation.
- identification of target market.
- economic alternatives to locals.
- development of public support.
- role of eco-tourism.
- promotion of biodiversity as a means of economic benefit (community-based awareness).
- formation of "grass-roots" network for environmental awareness.
- training components for educators/interpreters.
- use of rhino as a flagship species.
- *The need for more grass-roots promotion at the community level, through "extension agents", visiting schools, religion groups, farmer's meetings, etc.
- *issue of funding for programs.
- *clarification of the meaning of conservation within the context of the bureaucracy.
- *the need for basic information and training.

* Denotes concerns expressed by the Indonesian participants.

<u>Development and Implementation Strategies</u>

A. Changing community attitudes and awareness is a long-term task but is one that is critical. Its success depends on using a wide range of techniques, many of which will rely on existing Indonesian community structures and education traditions. What is needed as a priority is greater emphasis on conservation awareness activities designed and implemented in the context of local (e.g., community level or national) needs and structures.

B. Conservation awareness activities span all levels and strata of society (international, national, and local societies). Their principal purpose is to affect knowledge, attitudes, and practice. That is, they should be designed to help change behaviors from the policy level down through local communities.

C. Effective conservation awareness comprises eight stages:

1. The identification of practices which, if changed, would cause desired positive modifications in behaviors with respect to conservation and nature protection. Such changes might be either in the policy context or in the action of groups or individuals.

2. The identification of groups and/or individuals with the capacity or potential to cause the changes to occur.

3. The identification of the types of messages which might lead in some demonstrably direct way to the desired changes. These messages need to be relevant to the experiences and interests of the selected target group(s), so that they will be accepted and internalized.

4. The identification of the media which might most effectively channel the messages to the target audiences (e.g.,mass media, formal school systems, training programs, videos, targeted mailings, community meetings, etc.).

5. Specification of the content of the message(s) which would most effectively impact on the targeted audiences through the selected media of transmission.

6. Packaging of the message to assure that it achieves the objectives.

7. Implementation.

8. Evaluation, assessment, and adjustment as required. This should be an on-going process, which consciously considers the constraints.

Recommendations

The Community Relations Working group makes the following recommendations for rhino conservation in Indonesia:

- The formation of a network among educators to provide accurate, consistent information pertaining to;
  a. rhinos and their habitat.

b. educational and interpretive techniques.

- The identification of the specific needs of various interpretive groups.

- Intensive training for all educators in basic interpretive techniques.

- The intensification of grass-roots community liaison toward the socio-economic development of the communities living close to the bounderies of rhino habitats.

- Local communities be given a priority for employment in park activities and must have a significant role in the development of policies and park management.

- The promotion of co-operation between Governments, N.G.O's, private businesses, clubs, journalists, teachers, religious leaders and local groups etc towards improved environmental education.

- Use of the rhino as an example of the promotion of entire ecosystems (i.e. as a flagship species).

- Continue with the use of the rhino as symbol for the "Visit Indonesia decade" for the further promotion of the rhino.

- Definition of a specific "message" to be related to target audiences, efficient methods for disseminating this message and the identification of specific target groups.

A PRESENTATION BY PHILIP WELLS (SRS) OF A PROPOSAL TO CARRY OUT A CENSUS OF SUMATRAN RHINOS IN THE KERINCI SEBLAT NATIONAL PARK

Thank you chairman for the oportunity to talk today about a proposal that has been developed and some of the interesting and new techniques that will be used.

The proposal is for a survey of the Kerinci Seblat N.P. to establish the distribution of the Sumatran rhino and the size of the population. In addition the rhino ecology will be further investigated.

The field work will last for at least one year, hopefully starting in the in early 1992, and will be run by a joint Indonesian and UK team of eight people. The resulting output of this project will be to produce the base line information for a management plan for the Sumatran rhino in the park.

The project will be funded by a mixture of charities and other comercial organisations in the USA and Europe.

It is hoped that the project will work in close co-operation with the PHPA in support of their own efforts.

The survey will establish the distribution within the park and identify areas of absences or high concentrations of rhinos.

A detailed population count will be carried out in one area to determin the rhino density. The density calculated can be applied to the rhino distribution to estimate the total population in the park. The areas of absence and high concentration will be accounted for.

The principal method used for the population study will be the method of plaster casts as developed by Nico van Strien.

There will be other techniques used by the project, namely:

1. Hormonal Faecal Analysis
2. DNA Faecal Analysis
3. Infrasound detection

1. Hormonal Faecal Analysis

Fresh samples of faeces will be collected and appropriately stored before being sent to a laboratory either in the USA or Austria. The information that will be provided by this is; the sex of the animal, if female whether she is pregnant, and if sufficient samples are found, the oestrus cycle of the animal can be determined and compared to behavioural patterns.

This method has not been yet tried on the Sumatran rhino but it has been successful on the black rhino and other species.

2. DNA Faecal Analysis

Using the same samples of faeces found ~~In~~ and stored they will be sent for analysis in a UK laboratory. This analysis will be able to; sex the animal, 'fingerprint' an individual, and possibly establish the blood relations between different animals.

There are still technical problems that need to be overcome but the principles are well established. There will be limited control over the DNA analysis by the project as this work will be conducted by a seperate team.

3. Infrasound Detection

This will be a preliminary investigation by E. Muggenthaler, who presented a poster on infrasound production by rhinos at the San Diego Rhino Conference. The investigation will look at the application of infrasound for population counts and ecological studies. The particular areas that this will be directed towards are; counting techniques using fixed detectors in a similar manner to the photographic survey by Mike Griffiths, direction finding in a similar way to the use of radio collars except without any need for capture, seek to establish whether vocal signatures can be established for individual animals.

The van Strien method will provide the bulk of the data in this project but the DNA and faecal analysis and infrasound investigations if successful will have a great impact on all future research in the rhino. I would like to suggest that these may have great applicability to the Javan rhinoin the Ujung Kulon N.P.. The DNA analysis could provide a great insight into the social structure and breeding habits of the rhino.

Questions:

Dr R. Schenkel expressed concern that the project did not support conservation. Philip Wells responded that the project will provide the information in the Kerinci Seblat N.P. necessary for efficient conservation plans, and that the ecological information will be very helpful in planning translocation. It was stated that by expressing the applicability of these new techniques to the Ujung Kulon there was no suggestion that they should be used for a population count and duplicate other efforts.

Zainal Zahari B. Zainuddin expressed concern over the fact that these new techniques may not be successful. Philip Wells responded that there was a risk that they would not be successful but this would not affect the outcome of the survey as a majority of the time would be spent on the well established van Strien method.

STATUS REPORT ON SUMATRAN RHINO IN THE KERINCI SEBLAT NATIONAL PARK

By

Dudi Rufendi, Mega Haryanto, Widodo.

THANK YOU MR CHAIRMAN

MY NAME IS DUDI RUFENDI, CURRENTLY WORKING FOR PHPA WWF PROJECT IN KERINCI SEBLAT NATIONAL PARK.

SINCE MR MEGA HARYANTO AND MR WIDODO CAN NOT COME TO THIS WORKSHOP I WOULD LIKE TO PRESENT THIS PAPER ON BEHALF OF THEM.

THIS RHINO SURVEY WAS PART OF ONGOING AREA SURVEY IN THIS NATIONAL PARK STARTED IN SEPTEMBER 1990. ALL THE DATA WAS QUALITATIVE LY COLLECTED.

AT PRESENT KERINCI SEBLAT NATIONAL PARK OF 14,000 KM2, WAS DIVIDED INTO THREE BLOCK OF FOREST BY THE EXISTING ROAD ----> PETA KAWASAN
ALL THE ROAD FROM SUNGAI PENUH RADIATED TO TAPAN (IN THE WEST, MUARA LABUH (IN THE NORTH) AND TO BANGKO IN THE EAST.

KERINCI SEBLAT NATIONAL PARK IS BELIEVE AS THE MOST IMPORTANT SUMATRAN RHINO STRONGHOLD IN SUMATRA.

UNTIL 1980 THE FOREST AROUND THE PARK WAS IN GOOD CONDITION, AT PRESENT WITH THE INCREASING FOREST CONVERTION FOR LARGE ESTATE AND AGRICULTURE SETTLEMENT, ALL THE LOW LAND AND FOREST OUTSIDE THE PARK WAS GONE, IT PUSH LOCAL PEOPLE TO THE HILLY LAND CLOSE TO THE BORDER OF THE PARK FOLLOWING THE LOGGING ROAD.

THE GROUND SURVEY RESULT UP TO JULY 1991, THE SUMATRAN RHINO SEEN TO CONCENTRATED IN THE SOUTH EASTERN OF BLOCK THE PARK, SHOWED THE FREQUENCY OF SUMATRAN RHINO PRESENT ON THE 19 SURVEY STRIPS OF 24.------> PETA SEBARAN SEKARANG.

FROM THE TOPOGRAPHIC MAP, 42% OF THE RHINO PRESENT IN THE ALTITUDE OF 600 TO 1000 METER, AND 5% OF THE SUMATRAN RHINO FOUND IN LOW LAND FOREST IN THE ALTITUDE UNDER 400 METER.

FURTHER GROUND SURVEY WILL BE CARRIED OUT IN THE NORTH EASTERN BLOCK AND NORTH WESTERN BLOCK OF THE FOREST TO GET THE COMPLETE OVERVIEW OF SUMATRAN RHINO DISTRIBUTION IN THE PARK.

RECENTLY MR PHILIP WELLS FROM THE UK ALREADY PROPOSED AN INTENSIVE SUMATRAN RHINO SURVEY FOR THE PARK WHICH WILL CENCUS THE SUMATRAN RHINO IN THE KERINCI SEBLAT NATIONAL PARK.

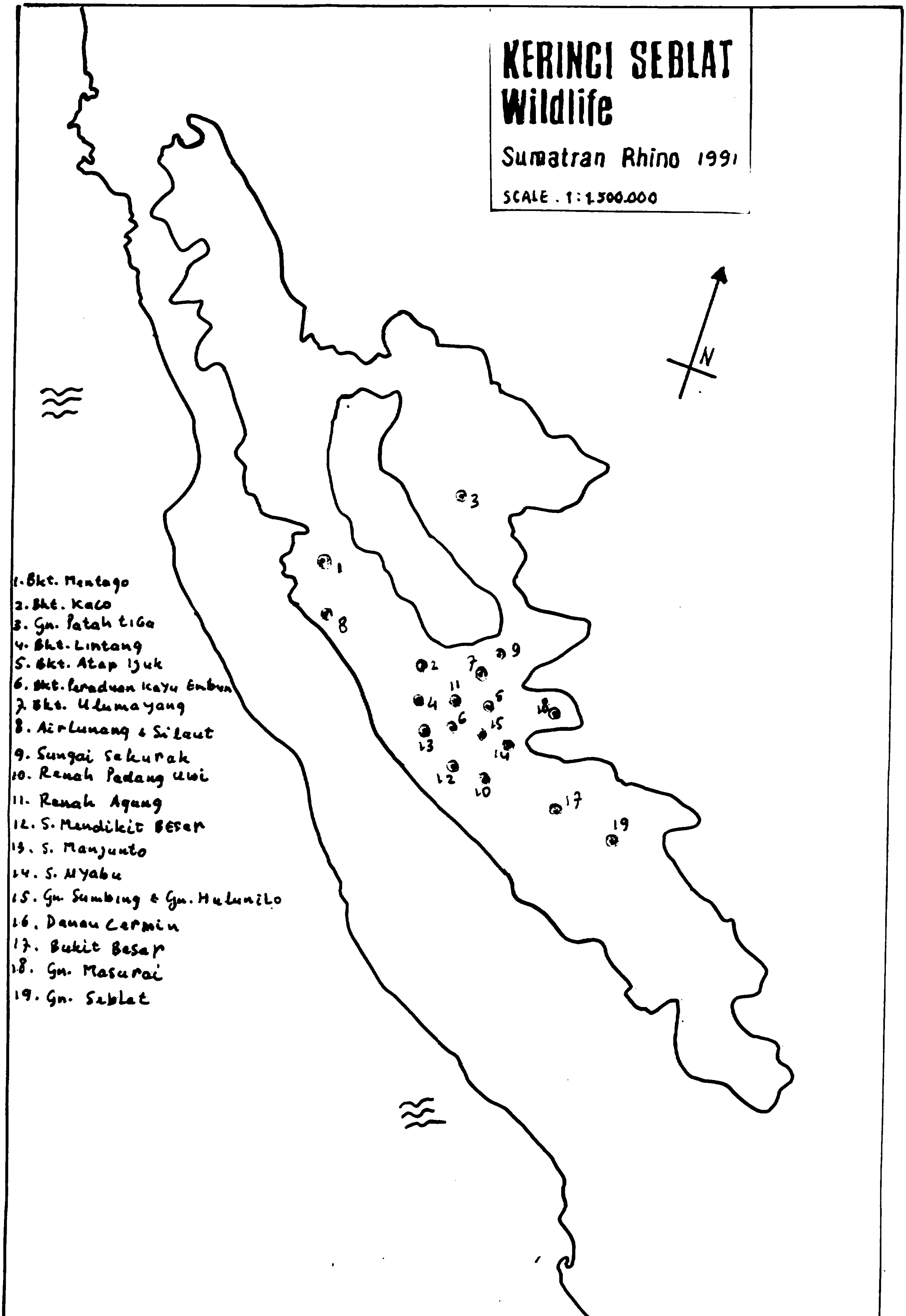
LAST YEAR THE PARK AUTHORITY DISCOVERED AT LEAST 6 RHINO HAS BEEN POACHED IN BENGKULU IN SIDE OF THE PARK. ALL THE POACHERS WAS

TAKEN TO THE COURT, RESULTING ONE TO THREE YEARS SENTENCED IN THE JAIL.

TO IMPROVE THE PROTECTION OF THE PARK FROM SUMATRAN RHINO POACHING, PHPA WILL START TO IMPLEMENT THE EXTENTION AND AWARENESS PROGRAMMES AND WORK MORE CLOSELY WITH THE LOCAL PEOPLE TO MONITOR AND DECREASE POACHING ACTIVITY, WHILE WAITING FOR OFFICIAL DECREE FOR THE PARK AND MAN POWER DEVELOPMENT.

TO INSURE THE CONTINUELY OF DATA COLLECTION AND CENCUS WE PROPOSE A MODEST RESEARCH STATION TO HOUSE THE FIELD EQUIPMENT AND VISITING SCIENTIST.

MORE SUPPORTS AND RESOURCES ARE NEEDED TO SAFEGUARD THE PARK FOR THE LONGTERM SURVIVAL OF SUMATRAN RHINO. IN THIS OPPORTUNITY I PROPOSE THE ZOO COMMUNITY TO ADOPT THIS BIGGEST NATIONAL PARK IN SUMATRA FOR THE FUTURE OF SUMATRAN RHINO.


KERINCI SEBLAT
Wildlife
Sumatran Rhino 1991
SCALE . 1: 1.500.000
N
1. Bkt. Mentago
2. Bkt. Kaco
3. Gn. Patah tiga
4. Bkt. Lintang
5. Bkt. Atap Ijuk
6. Bkt. Peraduan Kayu Embun
7. Bkt. Ulumayang
8. Air Lunang & Silaut
9. Sungai Sekurak
10. Renah Padang Uwi
11. Renah Agung
12. S. Mendikit Besar
13. S. Manjunto
14. S. Nyabu
15. Gn. Sumbing & Gn. Hulunilo
16. Danau Cermin
17. Bukit Besar
18. Gn. Masurai
19. Gn. Seblat

Priorities and Implementation Working Group

Members

Effendi Sumardja (Chair)
Mark Stanley-Price
Mohammed Khan bin Momin Khan
Nico van Strien
Chris Wemmer
Chrios Hails
Ross Hodder
Ajisasmito
W. Mustafa
Ron Tilson
Steve Hage
Tim Sullivan
Haris Surono
Sukianto

Working Groups

1) Management and Protection of Ujung Kulon National Park
2) Establishing Additional Javan Rhino Populations
3) Sumatran Rhino Ex-situ husbandry
4) Monitoring, Protecting and Controlling Trade of Sumatran Rhino
5) Indonesian Conservation Strategy for the Sumatran Rhino
6) Reintroduction and translocation protocols
7) Community relations and Communications

Existing Direct and Indirect Commitments to Rhino Conservation in Indonesia

1) WWF Project in Kerici Seblat public awareness: $100,000
2) WWF-Ujung Kulon: $60,000
3) WWF: Gunung Leuser, Sumatra: Community Studies, Bohorok Visitor Center: $80,000
4) New Zealand Government: : Ujung Kulon, $250,000
5) Minnesota Zoo: Ujung Kulon protection, $25,000
6) CUSO: Ujung Kulon Community Education and Park Interpretation . $20,000
7) WWF/Ford Foundation: Kayan Mentarang, Kalimantan: $250,000
8) Bank International Indonesia: Kerinci, Barisan Selatan, Ujung Kulon: 150,000 $US
9) World Bank: Forestry II, (10 sites, but only 3 are for rhino conservation areas): Barisan Selatan, Kutai, and Way Kambas: $300,000
10) Sumatran Rhino Trust: Sumatran Rhino Field Protection: $40,000
11) Global Environment Facility (GEF): Kerinci Seblat: 10 Million US$ (possibly)
12) World Bank Forestry I: Gunung Leuser Conservation, $1 million

13) Asian Wetland Bureau: Berbak Reserve (possible rhino reintroduction site), $40,000
14) Kaltim Primaco (International Coroporation): Kutai Action Plan, $130,000

Priorities with Funding Requisites

1) Protection, and monitoring of wild rhinoceros populations in existing strongholds; and surveying sites suspected of harboring populations (a discussion ensued on the methodology based on differing experiences of the participants)

2) Training of field personnel and the development of reliable censusing methodology

3) Convene a workshop to identify field and captive research priorities, especially ecology and behavior relevant to Sumatran rhinoceros conservation.

Priorities without or with minimal funding requisites

1) Gazetting of protected areas as National Parks with well defined boundaries, as listed in the Working Group 5 Recommendations

2) Conduct a feasibility study of potential sites (specifically Way Kambas) for the translocation of the Javan rhinoceros, and develop a translocation working plan.

3) Identify a priority site with an existing Sumatran population to receive additional rhinoceros from isolated populations, and develop a translocation work plan.

4) Secure tissue samples and necessary legal documents for the exportation of Sumatran rhino tissues for genetic analysis.

REPORT OF GROUP ON EVALUATION AND MONITORING OF IMPLEMENTATION

1. The group recommends the setting up of a body entitled "The Advisory Board of the Indonesian Rhinoceros Foundation".

2. The recommended composition of the Board is as follows:

i) Director of Conservation,PHPA
ii) Director of Species Conservation,PHPA
iii) Rhino Desk Officer,PHPA
iv) PHPA field officer concerned with Javan rhino
v) PHPA field officer concerned with Sumatran rhino
vi) University expert on rhino biology
vii) L.I.P.I.expert on rhino biology
viii) Rhino expert from another agency/dept.of Forestry
ix) Representative from WWF Indonesia programme
x) Field biologist from Asian Rhino Specialist Group
xi) International rhino biologist from outside ARSG
xii) Conservation plan evaluator
xiii) Population biologist from the captive breeding community.

It is emphasised that,as far as possible,individual membership of the Board should be constant and frequent changes of personnel are undesirable. Individuals selected for x) to xii) should be readily available to travel to Indonesia and have appropriate funding available for this purpose.

3. It is recommended that the Advisory Board should meet routinely every 2.5 years,in Indonesia. Every second meeting (i.e.at 5-yearly intervals) should undertake a major review,including translocation of the Javan rhino. In addition to its routine meetings,the Board is authorised to appoint ad hoc working groups,as neccessary,to address specific problems. Such groups may include appropriate members of the Board,as well as invited experts with knowledge of the specific problems under consideration.

4. The responsibilities of the Board shall be the giving of advice to PHPA on,and the periodic evaluation of,the following matters (either directly or via one of the working groups):-

a) Overall organisation and management pertaining to the conservation of both Javan and Sumatran rhinos.
b) Personnel,expertise,training in relation to rhino management.
c) Law enforcement and protection of rhinos.
d) Extension and public awareness.
e) Fund raising.
f) Partnership evaluation.
g) Implementation of management plans for the Javan rhino,including:
i) management of Ujong Kulon N.P.,including protection and data gathering.
ii) identification of reception sites for translocation.

iii) preparation of reception sites(strengthening protection,staff training,rhino reception/release facilities) as per translocation timetable (see iv) below).

iv) timing of initial and subsequent translocations.

v) number and sex/age composition of animals for each translocation.

vi) specific review and evaluation of translocation programme after 4.5 years and formulation of ongoing recommendations.

h) in situ programme for Sumatran rhino ,including management of key protected areas.

i) ex situ management of Sumatran rhino,both within Indonesia and overseas.

j) technical problems re capture and translocation.

k) emergency monitoring and unforeseen problems brought to the attention of the Board by PHPA or other concerned parties.

Working Group on Marketing and Fund-raising

5 October 1991

Herman Haruman
Kathy MacKinnon
Chris Schurmann
Mike Griffiths
Darryl Miller
Frans van Dongen
Philip Wells
George Rabb
Thomas Foose
Yansen Manasang

The Group identified the following issues and needs:

An overall programmatic budget for the comprehensive conservation program identified by Groups 1-7 which supplements and extends the Indonesian Rhino Conservation Plan presented by Effendy. We presumed that there would be further prioritization of the actions covered in the extended plan, and that PHPA would further review the resulting document. Commitment to the strategy by the government was regarded as essential to raising funds for additions to the existing program. It was recognized that the efforts of this workshop were constructed from a singularly rhino-specific viewpoint.

Components of such a budget for Sumatran Rhino include:

1. Monitoring and protection of the rhinos
2. Field research studies
3. Community relations and development, education
4. Strengthening of management and protection in the parks
5. Survey of Kalimantan
6. Translocation and identification and establishment of new sanctuaries within park areas
7. Project administration and management
8. Training
9. Captive breeding in Indonesia
10. Providing for sustainability of program (building in ongoing capacity as fund-raising and marketing proceeds)

(for Javan Rhino, omit 5 & 9)

A comparison of what parts of the extended strategic plan are presently being covered or could be from PHPA and other Indonesian government sources, and from other existing sources (World Bank Forestry I and II, Rhino Foundation, BII, WWF, Minnesota, New Zealand, etc), and what remains to be covered from new sources. It was recognized that objectives of the Rhino plan would have to be "packaged" in relation to the general programs and plans of PHPA and other government agencies, and tailored in such a way to tie in as well as possible to G.O.I. budgeting procedures and Bappenas priorities.

Potential new sources of funding identified were:

GEF funds (World Bank, UNEP, UNDP). K. MacKinnon indicated that as much as half of $20 million of the biodiversity grants for Indonesia might go to support

of ——> the Kerinci and surrounding areas.

ADBank (requires special program approach)

U.S.AID (ditto)

Other Foreign Govt. Aid programs (in particular EEC and the Netherlands)

Private Sector. Oil companies and other corporations

were ——> likely to give major support. (Kaltim Primacoal is already providing funds for Kutai.

Again, packaging of proposals was deemed very important in relation to the interests and programs of the potential donor. It is important to be able to document in-country commitments of resources when challenging outside donors for counterpart funding. It is also important to build in evaluation and accountability procedures to persuade donors of the sufficiency of the program. Frans van Dongen recommended that the budget in all instances recognize the difference between the immediate needs (one-off costs) and those that would have to be addressed for long term pursuit of the strategic plan by the Indonesian government. All agreed that sustainability of the program was paramount following the immediate, crisis responses.

Two human resource needs were specified for the ongoing work on fund-raising and marketing: a person familiar with the Indonesian governmental system and processes, and a person skilled in assembling proposals for conservation purposes. It was observed that the latter must be informed very closely by the parties carrying out the strategy. The value of an on-going advisory body was agreed to, and it was indicated that up to a year might be required to flesh out the fund-raising program and the budgets. Such instruments as the Heritage Species prototype proposal were regarded as valuable starts in an overall marketing and fund-raising program.

Closing Remarks

by

Mr. Mohd. Khan bin Momin Khan,
Chairman of the Asian Rhino Specialist Group (ARSG)

Ladies and Gentlemen,

I wish to take this opportunity to thank all participants for their contribution to this very important workshop on the Indonesian Rhino conservation. I have observed that everyone has actively participated and worked very hard to make the workshop a success. I believe that we have made a lot of progress during the last three days.

The presence of Mr. Sutisna Wartaputra, Director General of Forest Protection and Nature Conservation and Dr. George Rabb, Chairman of the IUCN - SSC is evidence of the importance of this workshop. We are obviously working on species that are not only endangered but are both delicate and sensitive. For that reason invitations have been extended to a lot of people who are known for their keen interest and expertise for the various areas of conservation of these species. I have also accepted everyone who wrote in to attend this workshop. These was absolutely no rejection of anyone.

At the start of the workshop I have urged everyone to actively participate and to be frank. I naturally would like to hope that no one had kept anything back and the results of this workshop represent all the comments and inputs made by all of us here. It is important to note that the objectives and recommendations have been made after lengthy discussions and they are the opinions of the majority if not all of us.

We have had most interesting three days workshop that brought to light a lot of new information. There were differences in oppinion but there was no doubt that the aims were the same and that was the conservation of the Asian rhinos.

I believe that the photographic survey by Dr. Michael Griffith must have aroused a great deal of interest. The application of this techniques is not only accurate but provide a lot of other data as well. Apart from identification of individual animals accurate data can also be collected on other species of wildlife which utilize the same habitat. There will be more accurate information on the number of animals, sex ratio, conditions of animals and even what they feed on from which accurate management decisions can be made.

We won't be groping in the dark. The situation would closely resemble that of the captive situation. We would know exactly what we are managing. It will be easier to describe if the efforts and money being put into the project are worthwhile. Justificatioon for funds will be more convincing and no doubt more successful. The work of field scientists will also be must easier compared to other more difficult techniques.

In the Plenary discussion various opinions were expressed on the Population Viability Analyisis. There was concern expressed by Dr. Rudy Schenkel on the release of captive bred animals, captive breeding itself and the success of the Sumatran rhino project was questioned. The results of these rather intense discussions resulted in more accurate data being made available as inputs for Population Viability Analysis. For example there was mortality data of the Javan rhino dating back to 1929 instead of the projected data based on an imagined annual mortality rate of one to one and one-half animals. There was also the comparative study of population censuses which provided additional information for the PVA. There were also discussions on causes of mortality such as disease, poisoning, natural disasters like forest fires' delebrate poaching.

Another controversial issue is the carrying capacity of Ujung Kulon whether it has reached the maximum carrying capacity at 55-60 animals. There is now a suggestion that there may be more than 70 animals with all these additional information the PVA will be more reliable.

There were eleven working groups in the last two days which have assembled a great deal of information on Rhino Conservation. The re-introduction and translocation protocols headed by DR. Marks Stanley Price touched among otherthings on the importance of history range, carrying capacity, flora meeting diet requirements, adequate water, wallows and minerals.

Dr. Chris Hails worked on management and protection of Ujung Kulon and touched on the goals and identified six key objectives in in-situ conservation. Among these are strong park adminsitration, establishment of regulation to enpower park guards to enforce the law, establishment of efficient communication, training and assessment of needs which are very important for management and protection.

Dr. Nigel Leader Williams working group worked on Rhino Biology which touched on life history, data on rhino numbers, PVA, and research which are all very important.

Dr. James Doherty's working group worked on ex-situ and husbandry program. The goal was to formulate and recommend minimum husbandry and management standards for existing captive populations of Sumatran Rhinos. The group made recommendations on housing, yards, diet, veterinary care, research, standardized daily reports and annual reports which are all very important to captive management.

Mr. Steve Hage's group worked on community relations and communications which are recommended for inclusion in Indonesia's conservation and development programs. A list of concerns were identified among which were poaching, deforestation, identification of target market, economic alternatives, training components, development and implementation of strategies, conservation awereness and implementation. Community relations and communication are not doubt very important to conservation.

The working groups on Conservation Strategy was headed by me. The group identified three goals of the Indonesian Rhino Strategy which are to sustain several large population for long term survival of the species. Acquire the knowledge necessary to sustain viable wild population and to reestablish Sumatran rhino populations within its former range. Gezettment of five major areas as national parks i.e: Gunung Leuser, Kerinci Seblat, Barisan Selatan, Kutai, Ujung Kulon and Way Kambas. We recommended among other things three types of conservation sites and there are protected areas, intensively managed Wild Rhino Sanctuaries and Captive Breeding Facilities.

Dr Nico van Strien chaired the working group on protocol for monitoring survey and protecting Sumatran populations. The group emphasized the importance of monitoring and anti-poaching terms to prevent poaching and to monitor populations. The primary aim is to prevent poaching. One of the qualifications is to recruit people in part from the locality of the key areas. They should have considerable knowledge of the rain forest and be given powers to apprehend poachers. Equipment is very important. The group also dealt with the need to have mobile and education units among other requirements.

I wish to take this opportunity to thank The Indonesian Government and in particular the local wildlife authorities for hosting this workshop. Dr Russell Betts of WWF and all his staff for organizing and taking care of logistics. Dr Linda has done all the documentation very efficiently and I like to thank her and her staff. Also the secretariat staff who have done an excellent job recording the proceedings. We are also grateful to Taman Safari Hotel especially Bapak Yansen for the accomodation, food, etc.

Thank you.

CLOSING ADDRESS

DIRECTOR GENERAL OF FOREST PROTECTION AND NATURE CONSERVATION OF THE MINISTRY OF FORESTRY

Honourable Guest, Chairman of The Asian Rhino Specialist Group, Chairman of The Captive Breeding Specialist Group of IUCN, Ladies and Gentlemen,

I am very happy and thank to all of you who have been gathering here to discuss and support the conservation of the world's rarest large mammals, the Javan and Sumatran Rhino.

Your experties and active participation is highly valuable and I appreciate it for the sake of the conservation of the rhinos.

The Indonesiân Government has committed to protect the nation's biodiversity with all effort and energy in order to improve our environment in a better condition. As the rhino's problem is not mine but ours, in this occasion, again, I urge all of you to keep sharing your experience and expertise to help us to protect our environment especially the conservation of the Javan and Sumatran rhino.

To The Safari Garden Hotel, I also would like to thank and appreciate for their support in having us here.

Within the spirit of Visit Indonesia Year 1991, and with the blessing of Allah Almighty, I officially closed the Workshop.

Thank you

SUTISNA WARTAPUTRA

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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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)

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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

CATASTROPHES

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)

REMOVALS

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

The Population Viability Assessment Workshop: A Tool For Threatened Species Management

by
Tim W. Clark, Gary N. Backhouse, and Robert C. Lacy

Introduction

Population viability assessment (PVA) is a procedure that allows managers to simulate, using computer models, extinction processes that act on small populations and therefore assess their long-term viability. In both real and simulated populations, a number of interacting demographic, genetic, environmental, and catastrophic processes determine the vulnerability of a population to extinction. These four types of extinction processes can be simulated in computer models and the effects of both deterministic and stochastic forces can be explored. In turn, the outcome of various management options, such as reducing mortality, supplementing the population, and increasing carrying capacity can also be simulated. Thus, PVA provides managers with a powerful tool to aid in assessing the viability of small populations and in setting target numbers for species recovery as a basis for planning and carrying out recovery programs. In addition, having performance-based management programs enables progress to be quantified and assessed. PVA also offers managers a powerful strategic planning and policy tool when vying for limited financial resources. This paper describes a PVA workshop that used a stochastic computer simulation to model small populations of, and explore management options for, six threatened/endangered wildlife species in Victoria, Australia.

The Workshop

The workshop was co-sponsored by the Department of Conservation and Environment (DCE), Victoria, and the Zoological Board of Victoria (ZBV), in cooperation with the Chicago Zoological Society (CZS) and was held at the Arthur Rylah Institute for Environmental Research (DCE), Heidelberg, Victoria, from May 28 through June 1, 1990.

The objectives of the workshop were to: 1) examine the adequacy of data on the six threatened species; 2) simulate the vulnerability to extinction by using PVA; 3) examine outcomes of various management options to restore the species; 4) estimate population targets needed for recovery planning; 5) evaluate the potential of PVA as a teaching aid to illustrate extinction processes and management options.

Mountain pygmy-possum — Photo by Ian McPherson

The six species were: mountain pygmy-possum, *Burramys parvus*; leadbeater's possum, *Gymnobelideus leadbeateri*; eastern barred bandicoot, *Perameles gunnii*; long-footed potoroo, *Potorous longipes*; orange-bellied parrot, *Neophema chrysogaster*, and helmeted honeyeater, *Lichenostomus melanops cassidix*.

The 32 people attending the workshop represented experienced field biologists and wildlife managers with detailed knowledge of these and other threatened species. A month prior to the workshop all participants were provided with background reading material (e.g. Shaffer 1981, Brussard 1985, Samson 1985, Gilpin 1989, and Lacy and Clark 1990). A questionnaire on life-history parameters to be completed on each species as a basis for entering values into the computer was also provided. Following an introduction and overview of PVA, the participants formed teams and commenced work. Simulations, analyses, and discussions were ongoing over the next five days. The first week concluded with a report and review of each team's progress. During the following week, teams further refined their simulations and commenced preparation of a final report with management recommendations.

Population Viability Analysis: The Vortex Model

The workshop used a computer program, VORTEX, to simulate demographic and genetic events in the history of a small population (<500 individuals). VORTEX was written in the C programming language by Robert Lacy for use on MS-DOS microcomputers. Many of the algorithms in VORTEX were taken from a simulation program, SPGPC, written in BASIC by James Grier (Grier 1980a, 1980b, Grier and Barclay 1988). See Lacy et al. 1989, Seal and Lacy 1989 and Lacy and Clark 1990 for earlier uses of VORTEX.

Life table analyses yield average long-term projections of population growth (or decline), but do not reveal the fluctuations in population size that would result from variability in demographic processes. When a population is small and isolated from other populations of conspecifics, these random fluctuations can lead to extinction, even in populations that have positive population growth on average. Fluctuations in population size can result from several levels of stochastic effects. Demographic variation results from the probabilistic nature of birth and death processes. Therefore, even if the probability of an animal reproducing or dying is always constant, the actual number reproducing or dying within any time interval would vary according to the binomial distribution with mean equal to the probability of the event (p), and variance given by $Vp = p*(1-p)/N$. Demographic variation is thus intrinsic to the population and occurs in the simulation because birth and death events are determined by a random process (with appropriate probabilities). Environmental variation (EV) is the variation in the probabilities of reproduction and mortality that occur because of changes in the environment on an annual basis (or other timescales).

VORTEX models population processes as discrete, sequential events, with probabilistic outcomes determined by a pseudo-random number generator. VORTEX simulates birth and death processes and the transmission of genes through the generations by generating random numbers to determine whether each animal lives or dies, whether each adult female produces broods of size 0, 1, 2, 3, 4, or 5 during each year, and which of the two alleles at a genetic locus are transmitted from each parent to each offspring. Mortality and reproduction probabilities are sex-specific. Mortality rates are specified for each pre-reproductive age class and for reproductive-age animals. Fecundity is assumed to be independent of age after an animal reaches reproductive age. The mating system can be specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors). Those males in the breeding pool all have equal probability of siring offspring.

Each simulation is started with a specified number of males and females in each pre-reproductive age class and the breeding age class. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus. The user specifies the severity of inbreeding depression which is expressed in the model as a loss of viability in inbred animals. The computer program simulates and tracks the fate of each population and then produces summary statistics on: the probability of population extinction over specified time intervals; the mean time to extinction of those simulated populations that went extinct; the mean size of populations not yet extinct; and the levels of genetic variation remaining in any extant populations.

A population carrying capacity specified by the user is imposed by a probabilistic truncation of each age class if, after breeding, the population size exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as linear increases or decreases across a specified number of years.

VORTEX models environmental variation simplistically (which is both an advantage and disadvantage of simulation modelling), by selecting at the beginning of each year the population age-specific birth rates, age-specific death rates, and carrying capacity from distributions with means equal to the overall averages specified by the user, and with variances also specified by the user. Unfortunately, rarely do we have sufficient field data to estimate the fluctuations in birth and death rates, and in carrying capacity, for a wild population. The population would have to be monitored long enough to separate sampling error statistically from demographic variation in the number of births and deaths, from annual variation in the probabilities of these events. Such variation can be very important in determining the probability of extinction, yet we rarely have reasonable estimates for most populations of conservation concern. If data on annual variation are lacking, a user can try various values, or model the fate of the population in the absence of any environmental variation.

Endangered Species
UPDATE

A forum for information exchange on endangered species issues
December 1990
Vol. 8 No. 2

Alice Clarke and Joel Heinen...Editors
Dr. Terry Root............Faculty Advisor
Jon Jensen.......................Staff Advisor

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The Endangered Species UPDATE welcomes articles related to species protection in a wide range of areas including but not limited to: research and management activities for endangered species, theoretical approaches to species conservation, and habitat protection and preserve design. Book reviews, editorial comments, and announcements of current events and publications are also welcome.

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Leadbeater's possum
(*Gymnobelideus leadbeateri*)
Photo by Jim Cooper

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VORTEX can model catastrophes as events that occur with some specified probability and which reduce survival and reproduction for one year. A catastrophe is determined to occur if a randomly generated number between 0 and 1 is less than the probability of occurrence (i.e. a binomial process is simulated). If a catastrophe occurs, the probability of breeding is multiplied by a severity factor that is drawn from a binomial distribution with a mean equal to the severity specified by the user. Similarly, the probability of survival for each age class is estimated in a similar manner.

VORTEX also allows the user to supplement or harvest the population for any number of years in each simulation. The numbers of immigrants and removals are specified by age and sex. VORTEX outputs the observed rate of population growth (mean of N[t]/N[t-1]) separately for the years of supplementation/harvest and for the years without such management, and allows for reporting of extinction probabilities and population sizes at whatever time interval is desired (e.g. summary statistics can be given at 5-year intervals in a 100-year simulation).

Overall, the computer program simulates many of the complex levels of stochasticity that can affect a population. Because it is a detailed model of population dynamics, often it is not practical to examine all possible factors and all interactions that may affect a population. The user, therefore, must specify those parameters that can be estimated reasonably, leave out of the model those that are thought not to have a substantial impact on the population of interest, and explore a range of possible values for parameters that are potentially important but very imprecisely known. A companion program, VORPLOTS, was used at the workshop to produce plots of mean population size, time to extinction, and loss of gene diversity from simulation results.

Equipment Required

VORTEX requires an MS-DOS microcomputer with at least 640K of memory. A math co-processor speeds up the program substantially. The VORPLOTS plotting program produces files in the Hewlett Packard Graphics Language (HPGL), for use on an HP plotter or equivalent.

A Kodak Dataview EGA enabled projection of a computer display via an overhead projector onto a large screen so that all participants could observe demonstrations of VORTEX during initial training.

Computers were used during the daily sessions primarily for exploratory analyses with relatively few runs (100 or fewer) of a simulation; more extensive analyses were run overnight. A test with 100 runs would take from 15 minutes to 3 hours, depending on the machine used and the size of the population being simulated.

The Workshop Results

Each team documented its activities and provided a preliminary report of the simulations completed, conclusions, an assessment of the conduct of the workshop, and the usefulness of the PVA process. Results will be published in peer-reviewed scientific journals by each team.

All cases showed similar results. First, most species and populations were highly susceptible to local extinction. Any further habitat loss or fragmentation or reduction in population size and density would result in rapid extinction. Second, in all cases, more field data would have been helpful. Third, management options to stave off extinction were identified and results simulated. Options included strict habitat protection, enhancement of existing habitat or restoration of lost habitat, captive breeding, and reintroduction of animals to existing habitat patches in which the species has become extinct in recent decades or to newly created habitat. Various combinations of management strategies were recommended for future management. Fourth, the simulations demonstrated that if proactive conservation management had been undertaken even 5 to 10 years ago when populations and habitats were considerably larger, the task of present day managers would be much more tractable. And fifth, improved conservation management for all six species is expected to result from the PVA exercise, enhanced research, and subsequent on-the-ground management. Three cases illustrate these conclusions: the mountain pygmy-possum (Mansergh et al. in prep.), eastern barred bandicoot (Myroniuk and Patrick in prep.), and orange-bellied parrot (Brown et al. in prep.).

Mountain Pygmy-Possum: The mountain pygmy-possum is a small marsupial restricted to alpine and sub-alpine (>1500m altitude) rock screes and boulderfields with heathlands. The species has been well studied and much information is available on its ecology (Mansergh 1989). Diet consists of invertebrates, seeds, and fruits. Breeding occurs from September to December, with litter size of 3 to 4. The young become independent by mid-January. Females can breed in their first year, and can live up to 9 years. An unusual feature of the life history of *Burramys* is the fact that sexes are segregated during the non-breeding season. The adult population is heavily biased towards females (6F:1M) because of the very high mortality experienced by males post-dispersal.

The current total population is estimated to be 2,300 breeding adults of which 80% are females. The species is regarded as vulnerable in Victoria and rare in New South Wales. The species is also susceptible to climatic changes associated with global warming.

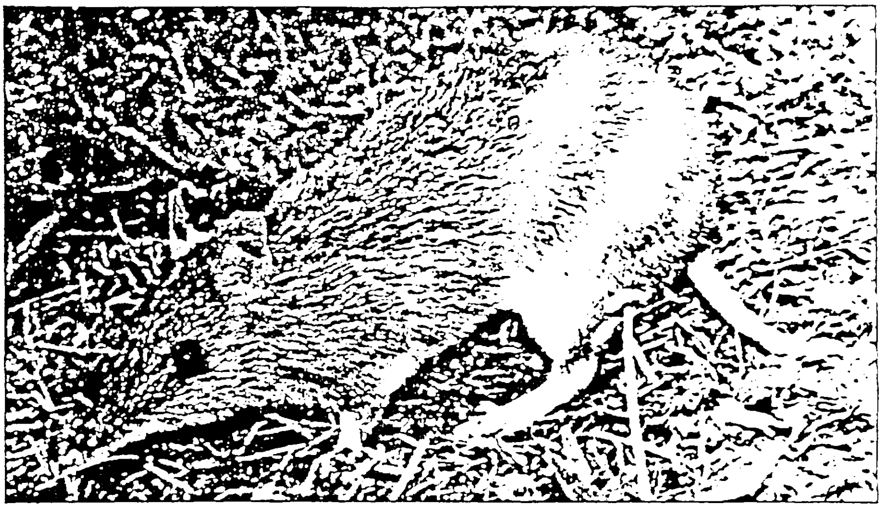
The mountain pygmy-possum exists as a number of discrete populations isolated from each other on mountain tops. A total of seven populations, ranging from 20-850 individuals (representing the situation in the wild) was modelled. High probabilities of extinction were observed in all small (<150 animals) populations at 25 and 50 years; this could account for the absence of the species from apparently suitable habitat within its range. The larger populations had a decreased likelihood of extinction. When modelled with a small but steady decrease in carrying capacity (1% per annum) such as could occur through climatic change with global warming, the probability of extinction increased greatly (to 45% in the case of the largest Victorian population of 850 individuals, over 50 years).

(Continued on UPDATE page 4)

Disturbance to habitat and further fragmentation of populations would increase the likelihood of extinction.

Eastern Barred Bandicoot: The mainland population of this marsupial species was formerly distributed over about 23,000 sq km of volcanic grassland in western Victoria. This population has now declined to 200 or fewer individuals restricted to remnant habitat near Hamilton (Clark and Seebeck 1990). The species is polygynous, with females capable of breeding from 3 months of age and males from 4 months of age. Gestation lasts about 12 days, with litters comprised of 1 to 5 offspring (usually 2-3); young remain in the pouch about 55 days. Females are capable of producing several broods per year. In spite of the very high reproductive potential, the population is believed to be declining at about 25% per annum. Juvenile mortality at dispersal from the nest is very high (> 90% within the first year). The decline of the species is attributed to habitat modification from pastoral activities and predation from introduced predators, including the red fox (*Vulpes vulpes*) and the cat (*Felis catus*).

Wild and captive populations of the eastern barred bandicoot were simulated. Modeling the wild population using available data without any change to current management indicated a 100% probability of extinction within 25 years, with a mean time to extinction of 7.2 years (± 2.1). Doubling the carrying capacity and leaving mortality unchanged had negligible impact on the probability of extinction and increased the mean time to extinction by only 2 years. Doubling the carrying capacity, reducing mortality by 30% and supplementing the wild population with the liberation of captive-bred animals greatly enhanced prospects for survival of the wild population. Under this scenario the probability of extinction was reduced to 0% over 25 years with a mean final population size of close to the carrying capacity of 300 animals. Modeling the existing and proposed captive populations allowed investigation of a variety of scenarios. The existing captive population of 16 pairs has an extinction probability of 83% over 25 years, with a mean time to extinction of 21.5 years. Doubling the number of adult pairs decreased the extinction probability to 0% but the surviving population had very low genetic variability, and there is little potential to harvest juveniles for release into the wild. Increasing the captive population to 62 adult pairs increased genetic variability and the potential to harvest juveniles without jeopardizing the captive population. Maintaining a captive population of 62 adult pairs (in two groups at separate locations to avoid catastrophe but managed as one population) and establishing two semi-captive populations with a capacity for 400 animals gave the best prospects for long term survival, maintenance of genetic variability, and production of sufficient offspring to consider reintroductions to suitable habitat within their former range. The exercise highlighted the need for a combination of management actions, rather than any single action, to prevent the almost certain extinction of the wild population under the existing management regime. Reduction of mortality by predator control and traffic management is essential for the survival of the eastern barred bandicoot. Captive management will be an important part of the recovery program, but with a more intensive program than that currently underway.



Eastern barred bandicoot — Photo by J. Seebeck

Orange-bellied Parrot: The biology and ecology of the orange-bellied parrot is comparatively well known (Loyn et al. 1986). The species is one of the rarest and most threatened birds in Australia, with a total population of 150-200 individuals. The orange-bellied parrot breeds in coastal southwest Tasmania in woodlands adjoining extensive sedgelands. After breeding, it migrates across Bass Strait to overwinter in coastal regions of southern mainland Australia. The birds feed in a variety of coastal habitats including grassland, saltmarsh, and dune systems, showing strong preferences for particular habitats and food types in different parts of their winter range and at different times of the year. An estimated 40 breeding pairs annually produce a total of 50-70 juveniles. The orange-bellied parrot is considered endangered. Loss of coastal habitat for development and trapping for the aviculture trade are considered to be the primary causes of the species' past decline. Pressures for development on or adjacent to its main wintering areas and habitat alteration are now the main threats to its survival. A captive breeding program is now underway as part of a range of measures undertaken to ensure the future survival of the species.

Populations were modelled using the current carrying capacity (150), a reduced carrying capacity (50), and an increased carrying capacity (500). Simulations which involved varying mortality, capture, and supplementation rates of the wild population were run for all carrying capacities. Simulating the existing population using current data and management regimes indicated that the species would remain extant over the next 50 years at least, and stood a good chance of surviving for 100 years.

Reducing the carrying capacity to 50 under current conditions somewhat surprisingly did not increase the probability of extinction over 50 years, although genetic variability was greatly diminished. As would be expected, increasing the carrying capacity to 500 birds further reduced the prospects of extinction and greatly increased the genetic variability of the population. When modelled with an increased juvenile mortality rate (75% cf 50%), the population with the reduced carrying capacity showed a 70% probability of extinction within 50 years, while the current and increased carrying capacity populations showed extinction probabilities of 20% within that time. Imposing a capture and release captive breeding program on the populations only slightly decreased the extinction probability of the reduced carrying capacity, high mortality population, but greatly improved heterozygosity in the reduced carrying capacity, current mortality population. No extinctions occurred in the current and increased carrying capacity populations even at the high mortality levels, when simulated with supplementation from a captive breeding program. The simulations indicate several points. Juvenile mortality is of great significance to the health of the population. Any increase above the present rate of 50% greatly increases the probability of extinction, even with an enhanced habitat carrying capacity. The captive breeding program is an important back-up to the wild population, and will be extremely valuable if the wild population declines.

Evaluation of the Workshop

An evaluation was considered to be an important part of the workshop. All participants rated the background material supplied prior to the workshop as good to very good. Provision of background material was essential as very few participants had any prior experience with PVA. Organization was rated as very good to excellent by participants. The key to success was the large number of microcomputers available so that 2 to 3 people per computer was possible. Presentations were rated as very good to excellent.

The workshop format was considered to be a highly successful way of presenting PVA. PVA was considered to be a useful tool to aid threatened species management, providing its application and limitations were understood. PVA can focus attention on questions that should be addressed through additional research. PVA can be applied to well-studied taxa, and the general principles can be applied more widely to other taxa providing program characteristics are kept in perspective. All participants would recommend PVA as a management tool.

Conclusions

The PVA workshop proved a very useful way of quickly learning a new technique for threatened species management and conservation. PVA was applied to six species allowing a critical, quantitative analysis of extinction probabilities, as well as exploring management options to prevent species loss. PVA results will be used in forthcoming management plans and actions directed towards restoring these species to a status from which they will be relatively immune to extinction from random processes. In the future, it can be expected that PVA's will be carried out on additional endangered species to help manage their recovery.

Acknowledgements

Several people and organizations made this workshop a success. Rod Gowans, DCE; Gerry Griffin, ZBV; Pam Parker and George Rabb, CZS, supported the idea and supplied resources and staff time to permit its realization. Gary Backhouse, DCE, and Amanda Embury, ZBV, organized the workshop. The Wildlife Information Management Unit of DCE acquired and set up the equipment. Each of the species teams contributed information for this paper, and Simon Bennett, DCE, contributed the equipment section. David Baker-Gabb and Andrew Bennett, DCE, reviewed an earlier draft and Denise Casey and Cathy Patrick, Northern Rockies Conservation Cooperative, USA, critically reviewed the final manuscript.

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VORTEX
Simulation model of stochastic population change

Written by Robert Lacy
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21 August 1991

STOCHASTIC SIMULATION OF POPULATION EXTINCTION

Life table analyses yield average long-term projections of population growth (or decline), but do not reveal the fluctuations in population size that would result from variability in demographic processes. When a population is small and isolated from other populations of conspecifics, these random fluctuations can lead to extinction even of populations that have, on average, positive population growth. The VORTEX program (earlier versions called SIMPOP and VORTICES) is a Monte Carlo simulation of demographic events in the history of a population. Some of the algorithms in VORTEX were taken from a simulation program, SPGPC, written in BASIC by James Grier of North Dakota State University (Grier 1980a, 1980b, Grier and Barclay 1988).

Fluctuations in population size can result from any or all of several levels of stochastic (random) effects. Demographic variation results from the probabilistic nature of birth and death processes. Thus, even if the probability of an animal reproducing or dying is always constant, we expect that the actual proportion reproducing or dying within any time interval to vary according to a binomial distribution with mean equal to the probability of the event (p) and variance given by $Vp = p * (1 - p) / N$. Demographic variation is thus intrinsic to the population and occurs in the simulation because birth and death events are determined by a random process (with appropriate probabilities).

Environmental variation (EV) is the variation in the probabilities of reproduction and mortality that occur because of changes in the environment on an annual basis (or other timescales). Thus, EV impacts all individuals in the population simultaneously -- changing the probabilities (means of the above binomial distributions) of birth and death. The sources of EV are thus extrinsic to the population itself, due to weather, predator and prey populations, parasite loads, etc.

VORTEX models population processes as discrete, sequential events, with probabilistic outcomes determined by a pseudo-random number generator. VORTEX simulates birth and death processes and the transmission of genes through the generations by generating random numbers to determine whether each animal lives or dies, whether each adult female produces broods of size 0, or 1, or 2, or 3, or 4, or 5 during each year, and which of the two alleles at a genetic locus are transmitted from each parent to each offspring. Mortality and reproduction probabilities are sex-specific. Fecundity is assumed to be independent of age (after an animal reaches reproductive age). Mortality rates are specified for each pre-reproductive age class and for reproductive-age animals. The mating system can be specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors). Those males in the breeding pool all have equal probability of siring offspring.

Each simulation is started with a specified number of males and females of each pre-reproductive age class, and a specified number of male and females of breeding age. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus, and the user specifies the severity of inbreeding depression (expressed in the model as a loss of viability in inbred animals). The computer program simulates and tracks the fate of each population, and outputs summary statistics on the probability of population extinction over specified time intervals, the mean time to extinction of those simulated populations that went extinct, the mean size of populations not yet extinct, and the levels of genetic variation remaining in any extant populations.

Extinction of a population (or meta-population) is defined in VORTEX as the absence of either sex. (In some earlier versions of VORTEX, extinction was defined as the absence of both sexes.) Recolonization occurs when a formerly extinct population once again has both sexes. Thus, a population would go "extinct" if all females died, and would be recolonized if a female subsequently migrated into that population of males. Populations lacking both sexes are not considered to be recolonized until at least one male and at least one female have moved in.

A population carrying capacity is imposed by a probabilistic truncation of each age class if the population size after breeding exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as linear increases or decreases across a specified numbers of years.

The user also has the option of modelling density dependence in reproductive rates, i.e., one can simulate a population that responds to low density with increased (or decreased) breeding, or that decreases breeding as the population approaches the carrying capacity of the habitat. To model density-dependent reproduction, the user must enter the parameters (A, B, C, D, and E) of the following polynomial equation describing the proportion of adult females breeding as a function of population size:

$$\text{Proportion breeding} = A + BN + CN^2 + DN^3 + EN^4$$

in which N is total population size. Note that the parameter A is the proportion of adult females breeding at minimal population sizes. A positive value for B will cause increasing reproduction with increasing population sizes at the low end of the range. Parameters C, D, and E dominate the shape of the density dependence function at increasingly higher population sizes. Any of the values can be set to zero (e.g., to model density dependence as a quadratic equation, set D = E = 0). To determine the appropriate values for A through E, a user would estimate the parameters that provide the best fit of the polynomial function to an observed (or hypothetical) data set. Most good statistical packages have the capability of doing this. Although the polynomial equation above may not match a desired density dependence function (e.g., Logistic, Beverton-Holt, or Ricker functions), almost any density dependence function can be closely approximated by a 4th-order polynomial.

After specifying the proportion of adult females breeding, in the form of the polynomial, the user is prompted to input the percent of successfully breeding females that produce litter sizes of 1, 2, etc. It is important to note that with density dependence, percents of females producing each size litter are expressed as percents of those females breeding, and the user does not explicitly enter a percent of females producing no offspring in an average year. (That value is given by the polynomial.) In the absence of density dependence, the user must specify the percent of females failing to breed, and the percents producing each litter size are percents of all breeding age females (as in earlier versions of VORTEX). Read the prompts on the screen carefully as you enter data, and the distinction should become clear.

VORTEX models environmental variation simplistically (that is both the advantage and disadvantage of simulation modelling), by selecting at the beginning of each year the population age-specific birth rates, age-specific death rates, and carrying capacity from distributions with means and standard deviations specified by the user. EV in birth and death rates is simulated by sampling binomial distributions, with the standard deviations specifying the annual fluctuations in probabilities of reproduction and mortality. EV in carrying capacity is modelled by sampling a normal distribution. EV in reproduction and EV in mortality can be specified to be acting independently or jointly (correlated in so far as is possible for discrete binomial distributions).

Unfortunately, rarely do we have sufficient field data to estimate the fluctuations in birth and death rates, and in carrying capacity, for a wild population. (The population would have to be monitored for long enough to separate, statistically, sampling error, demographic variation in the number of breeders and deaths, and annual variation in the probabilities of these events.) Lacking any data on annual variation, a user can try various values, or simply set EV = 0 to model the fate of the population in the absence of any environmental variation.

VORTEX can model catastrophes, the extreme of environmental variation, as events that occur with some specified probability and reduce survival and reproduction for one year. A catastrophe is determined to occur if a randomly generated number between 0 and 1 is less than the probability of occurrence (i.e., a binomial process is simulated). If a catastrophe occurs, the probability of breeding is multiplied by a severity factor specified by the user. Similarly, the probability of surviving each age class is multiplied by a severity factor specified by the user.

VORTEX also allows the user to supplement or harvest the population for any number of years in each simulation. The numbers of immigrants and removals are specified by age and sex. VORTEX outputs the observed rate of population growth (mean of N[t]/N[t-1]) separately for the years of supplementation/harvest and for the years without such management, and allows for reporting of extinction probabilities and population sizes at whatever time interval is desired (e.g., summary statistics can be output at 5-year intervals in a 100-year simulation).

VORTEX can track multiple sub-populations, with user-specified migration among the units. (This version of the program has previously been called VORTICES.) The migration rates are entered for each pair of sub-populations as the proportion of animals in a sub-population that migrate to another sub-population (equivalently, the probability that an animal in one migrates to the other) each year. VORTEX outputs summary statistics on each subpopulation, and also on the meta-population. Because of migration (and, possibly, supplementation), there is the potential for population recolonization after local extinction. VORTEX tracks the time to first extinction, the time to recolonization, and the time to re-extinction.

Overall, the computer program simulates many of the complex levels of stochasticity that can affect a population. Because it is a detailed model of population dynamics, it is not practical to examine all possible factors and all interactions that may affect a population. It is therefore incumbent upon the user to specify those parameters that can be estimated reasonably, to leave out of the model those that are believed not to have a substantial impact on the population of interest, and to explore a range of possible values for parameters that are potentially important but very imprecisely known.

VORTEX is, however, a simplified model of the dynamics of real populations. One of its artificialities is the lack of density dependence of death rates except when the population exceeds the carrying capacity. Another is that inbreeding depression is modelled as an effect on juvenile mortality only; inbreeding is optimistically assumed not to effect adult survival or reproduction.

VORTEX accepts input either from the keyboard or from a data file. Whenever VORTEX is run with keyboard entry of data, it creates a file called VORTEX.BAT that contains the input data, ready for resubmission as a batch file. Thus, the simulation can be instantly rerun by using VORTEX.BAT as the input file. By editing VORTEX.BAT, a few changes could easily be made to the input parameters before rerunning VORTEX. Note that the file VORTEX.BAT is over-written each time that VORTEX is run. Therefore, you should rename the batch file if you wish to save it for later use. By using data file input, multiple simulations can be run while the computer is unattended. (Depending on the computer used, the simulations can be relatively quick -- a few minutes for 100 runs -- or very slow.) Output can be directed to the screen or to a file for later printing. I would recommend that VORTEX only be used on a 80386 (or faster) computer with a math co-processor. It should run on slower machines, but it might be hopelessly slow.

The program can make use of any extended memory available on the computer (note: only extended, not expanded, memory above 1MB will be used), and the extra memory will be necessary to run analyses with the Heterosis inbreeding depression option on populations of greater than about 450 animals. To use VORTEX with expanded memory, first run the program TUNE, which will customize the program EX286 (a Dos Extender) for your computer. If TUNE hangs up DOS, simply re-boot and run it again (as often as is necessary). This behavior of TUNE is normal and will not affect your computer. After TUNEing the Dos Extender, run EX286, and then finally run VORTEX. TUNE needs to be run only once on your computer, EX286 needs to be run (if VORTEX is to be used with extended memory) after each re-booting of the computer. Note that EX286 might take extended memory away from other programs (in fact it is better to disable any resident programs that use extended memory before running EX286); and it will release that memory only after a re-boot. If you have another extended memory manager on your system (e.g., HIMEM.SYS), you will have to disable it before using EX286.

VORTEX uses lots of files and lots of buffers. Therefore, you may need to modify the CONFIG.SYS file to include the lines

FILES=25
BUFFERS=50

in order to get the program to run.

VORTEX is not copyrighted nor copy protected. Use it, distribute it, revise it, expand upon it. I would appreciate hearing of uses to which it is put, and of course I don't mind acknowledgement for my efforts. James Grier should also be acknowledged (for developing the program that was the base for VORTEX) any time that VORTEX is cited.

A final caution: VORTEX is continually under revision. I cannot guarantee that it has no bugs that could lead to erroneous results. It certainly does not model all aspects of population stochasticity, and some of its components are simply and crudely represented. It can be a very useful tool for exploring the effects of random variability on population persistence; but it should be used with due caution and an understanding of its limitations.

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Lindenmayer, D.B., V.C. Thomas, R.C. Lacy, and T.W. Clark. 1991. Population Viability Analysis (PVA): The concept and its applications, with a case study of Leadbeater's Possum, Gymnobelideus leadbeateri McCoy. Report to the Forest and Timber Inquiry (Resource Assessment Commission), Canberra, Australia. 170 pp.

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Seal, U.S. and R.C. Lacy. 1990. Florida Key Deer (Odocoileus virginianus clavium) population viability assessment. Report to the U.S. Fish and Wildlife Service. IUCN SSC Captive Breeding Specialist Group, Apple Valley, Minnesota.

WORKSHOP AGENDA

Thursday, October 3

CHAIR PERSON	Moch Khan B. Momin Khan
8:20 - 8:35	OPENING ADDRESS Sutisna Wartaputra
8:35 - 8:40	INTRODUCTION George Rabb
8:40 - 9:00	OBJECTIVES AND OVERVIEW OF MEETING Simon N Stuart
9:00 - 9:30	REVIEW OF ASIAN RHINO SPECIALIST GROUP ACTION PLAN FOR INDONESIA Moch. Khan B. Momin Khan
9:30 - 9:35	DESCRIPTION OF NEW INDONESIAN RHINO FOUNDATION Sutisna Wartaputra, Effendy A. Sumardja
9:38 - 10:00	INDONESIAN RHINO CONSERVATION PLAN Abdul Bari T.S., Effendy A. Sumardja, Sukianto Lusli
10:00 - 10:42	BREAK
10:42 - 11:24	FACTS OF JAVAN RHINO BIOLOGY AND EXPERIENCE OF CONSERVATION MEASURES AS A BASIS FOR STRATEGY CHOISE Schenkel
11:24 - 11:55	REVIEW OF JAVAN RHINO PVA RESULTS AND RECOMMENDATIONS Ulysses Seal, Thomas J. Foose & R. Lacy
11:55 - 12:05	DECISION ANALYSIS Nico van Strien
12.05 - 12.15	SUMATRAN RHINO CAPTURE IN 1959-1960 Boeadi
12:15 - 12:22	STATUS OF SUMATRAN RHINO IN SABAH Mahedi Andau
12:28 - 12:33	INTERNATIONAL STUDBOOK FOR SUMATRAN RHINO Thomas J. Foose
12:33 - 12:40	DISCUSSION
12.40 - 13.45	LUNCH
13:45 - 13:55	SUCCESSES AND FAILURES IN AFRICAN RHINO CONSERVATION Leader Williams
13:55 - 14:10	SUCCESSES AND FAILURES IN INDIAN RHINO CONSERVATION Deb Roy, Sale
14:10 - 14:36	REVIEW OF ONGOING RHINO CONSERVATION PROGRAMS Jim Doherty, Kathy MacKinnon, Russell H. Betts
14:36 - 14:40	SUMATRAN RHINO CAPTIVE BREEDING MANAGEMENT PLAN Linda Prasetyo
14:40 - 14:55	DRAFT GLOBAL STRATEGY FOR THE SUMATRAN RHINO Thomas J. Foose
15:20 - 16:00	BREAK
16:00 - 18:00	OVERALL PLENARY DISCUSSION Simon N. Stuart
18:00 - 20:30	DINNER
20:30 - 22:00	WORKING GROUP

Friday, October 4

08:00 - 08:45	UJUNG KULON PHOTOGRAPHIC SURVEY Mike Griffith
08:45 - 10:30	WORKING GROUPS
10:30 - 11:00	BREAK
11:00 - 11:30	WORKING GROUPS
11:30 - 12:00	REPORT OF WORKING GROUP RESULTS
12:00 - 13:00	LUNCH
13:00 - 16:00	WORKING GROUPS
16:00 - 16:30	BREAK
16:30 - 18:30	WORKING GROUPS
18:30 - 19:00	REPORT OF WORKING GROUPS RESULTS
19:00 - 20:00	DINNER
20:00 - 24:00	WORKING GROUPS

Saturday, October 5

08:00 - 08:30	A PROPOSAL TO CENSUS THE SUMATRAN RHINO IN THE KERINCI SEBLAT NATIONAL PARK Philip Wells
08:30 - 9:00	STATUS REPORT ON SUMATRAN RHINO IN THE KERINCI SEBLAT NATIONAL PARK Mega haryanto, Widodo, & Dudi Rufendi
09:00 - 10:30	WORKING GROUPS EVALUATION
10:30 - 11:00	BREAK
11:00 - 12:30	WORKING GROUPS EVALUATION
12:30 - 13:30	LUNCH
13.30 - 15.30	REPORT OF WORKING GROUPS EVALUATION : 1. PRIORITIES AND IMPLEMENTATION 2. EVALUATION AND MONITORING OF IMPLEMENTATION 3. MARKETING AND FUND RAISING
15:30 - 16:00	BREAK
16:00 - 16:45	FINAL PLENARY DISCUSSION
16:45 - 16:55	CLOSING REMARKS Moh. Khan bin Momin Khan
16.55 - 17.00	CLOSING ADDRESS Sutisna Wartaputra

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Vice Chairman	:	Haris Soerono
Secretary	:	Muladi Wijaya
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