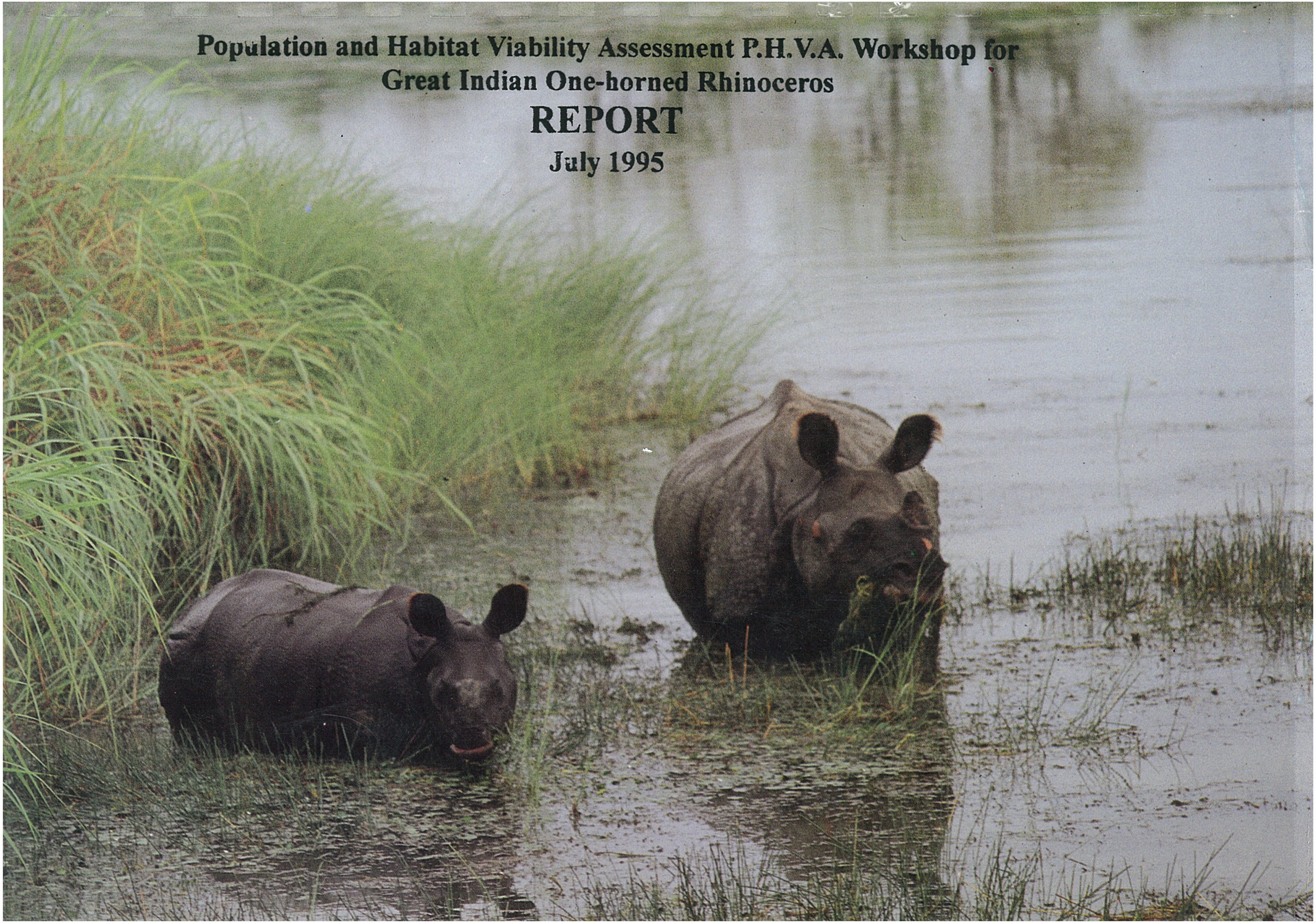
Population and Habitat Viability Assessment P.H.V.A. Workshop for Great Indian One-horned Rhinoceros

REPORT

July 1995



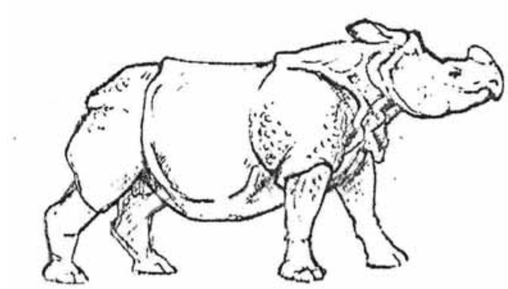
REPORT

Population and Habitat Viability Assessment
(P.H.V.A) Workshop

Great Indian One-horned Rhinoceros
Jaldapara, 1993,

Forest Department of West Bengal
Ministry of Environment, Govt of India
Asian Rhino Specialist Group
Conservation Breeding Specialist Group, SSC, IUCN
Zoo Outreach Organization/CBSG, India

Edited by
Sanjay Molur, Raman Sukumar, Ulysses Seal, Sally Walker
Coimbatore, August 1995



Contents

REPORT

August 1995, Coimbatore
Population and Habit Viability Assessment
P.H.V.A. workshop for Great Indian One-Horned Rhinoceros
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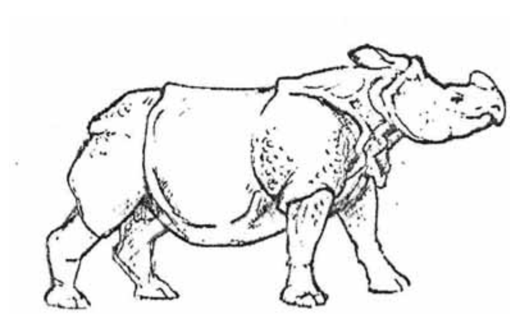
Section I

Executive Summary And Recommendations



Executive Summary

A Population and Habitat Viability Analysis Workshop for the Great India Rhino was conducted for three days in Jaldapara Wildlife Sanctuary with a day spent in the Gorumara Wildlife Sanctuary, along with concurrent sessions of the Asian Rhino Specialist Group. The PHVA was organised by the Forest Department of West Bengal and sponsored jointly by the Department, the Ministry of Environment and Forests, Government of India and the Asian Rhino Specialist Group. Some of the members of the AsRSG participated in Working Groups for the PHVA. Parallel Working group sessions were held alternately with Plenary, or reporting sessions. Written reports were prepared by all of the Working Groups which form this Report.

The Working Groups included:

1. Population and Habitat Dynamics
2. Management Strategies
3. Trade
4. Human Impact
5. Public Awareness
6. Funding requirements
7. Translocation and Reintroduction
8. Captive Breeding and Disease Management
9. Population Modelling

The Population and Habitat Dynamics Working Group attempted to quantify and assess population parametres using data on population structure, number and density obtained from the forest department, and habitat requirements using information on the behavioural and biological characteristics of the Indian rhino.

The present populations in the six protected areas varies from 30% to 65% of their respective estimated carrying capacity. In all the protected areas the growth rate of the population is relatively less compared to the rate of mortality, mostly due to the high rate of poaching. Analysis of adverse factors indicated that flooding and grazing were the most frequently occurring.

The Modelling Group considered scenarios in all of the rhino habitats and ran models both taking into account the general parameters existing in all of the habitats and more specific scenarios as applied to some of the smaller populations. Recommendations were made looking at the existing conditions and the future predictions. It was noted that four of the five small populations of Jaldapara, Gorumara, Pobitora and Manas were under threat of extinction if poaching continued unabated. The population at Gorumara is needed to be managed more intensely with supplementation for it is too small to survive on its own. The models showed that all of the populations to survive on its own. The models showed that all of the populations to survive for the next 100 years with no poaching and with good metapopulation management strategies.

The Working Group for Management Strategies focused on the preservation of existing biodiversity with emphasis on maintenance or attainment of ecologically viable populations of Indian rhino. Recommendations were made to provide genetic continuity through expansion of existing organisational structure to orchestrate, coordinate and intensify anti-poaching measures. Vegetation and water management for all areas was recommended.

Special management measures were suggested for medium and small populations, such as the identification and inclusion of additional habitat and improvement of existing habitat. For small populations it was suggested additionally that they be maintained as a genetic resource to facilitate research of reproductive biology of small populations and translocation of compatible breeding stock from one area to another. Other strategies for all rhino bearing areas were economic recovery of fringe human population, wildlife tourism, training, monitoring and veterinary care.

The Threats Working Group divided into three separate groups related to trade, which directed their attention to the subjects of Trade, Human Impact and Public Awareness respectively.

The Trade Working Group centred their discussion on the rhino horn, including legal structures at the international and national levels. They recommended measures for enhancing enforcement and dealing with poaching techniques, poaching pressures, market trends, trade routes. Substitutes for rhino horn usage were suggested.

The Human Impact Working Group addressed the topic of communities in proximity to the protected areas for the rhino, including demographic changes, patterns of dependency, attitudinal changes, socio-economics, and political/civil unrest.

The Public Awareness Working Group analyzed people’s participation and NGO involvement, motivation of service personnel, education extension, interpretation programmes and eco-tourism.

The Captive Breeding and Disease Management Working Group looked at the history of rhino management in India and made recommendations on the basis of their past performance and present facilities including holdings of animals. It was felt that zoos that have had breeding successes should be given priority when pairing animals and that all efforts must be taken to assure maximum breeding potential. Specific recommendations were made in this regard. It was also felt that Guwahati Zoo should not be used as an orphanage as this arrangement affects the management of the existing captive population there. It was felt that surplus males could be used for reintroduction research. In repect of health and disease the working group felt that more information and research was essential on neonatal mortality, infectious disease survey and post-mortem results of rhinos in captivity.

The Translocation and Reintroduction Working Group discussed means of 1.streng-thening non-viable populations and 2. establishing new populations by reintroduction. The following factors were stressed : areas which have recently lost rhinos should be "preferred" but only where the original causes of extermination/extinction have been removed or are in the process of being removed and where habitat requirements of the species have been satisfied; the extent of recipient areas must have adequate rhino habitat for a minimum of 100 individuals; the area should have the strictest possible legal protection status with good implementation of enforcement measures; the areas should have a management plan and adequate overall infrastructure. Monitoring should be carried out on released animals.

The Funding Requirements Working Group did a costing of the requirements for all five areas for submission to international aid agencies under broad categories, e.g., Reinforcement of infrastructure for anti- poaching measures, Habitat management, Veterinary and rescue of marooned animals, Security Staff support, Eco- development, Compensation payment, Translocation/Reintroduction of animals, Wildlife Tourism and Awareness, Training Research and Monitoring.

P.H.V.A. for Indian Rhinoceros Combined Recommendations

Population Modelling

1. The modelling exercise demonstrated that if a management goal of 70 rhinos for Jaldapara is considered, the present population may take 15-25 years to grow to this level through normal reproduction and births if no additional poaching occurs. This size population is a viable sub-population in a metapopulation management strategy.
2. According to the modelling exercise, the Jaldapara population at the present status and growth rate cannot sustain an annual poaching rate of even 2% or one rhino per year.
3. At the present rate of growth and the initial number of animals, the model showed the Jaldapara population to be inbred (heterozygosity retained may be around 75%). Supplementation of fresh lines into this population at intervals will increase the gene diversity and the viability of the population.
4. The Gorumara population will require intensive management and frequent supplementation to survive demographic, stochastic and potential inbreeding depressions from genetic drift.
5. A metapopulation management strategy needs to be developed taking into account the population trends in each area, the currrent and expected habitat availability and quality and the levels of which poaching can be controlled. Given the small area available, it may be that the Gorumara population will not recover unless poaching is controlled.
6. The estimated total rhino numbers is 1400-1500 in 6 populations with the Kaziranga population comprising 1100+ of the total. The modelling shows that four of the five smaller populations (except Gorumara) are potentially viable in 100 year projections if poaching can be controlled. Poaching is an important factor in the nonviability of populations. Stringent steps must be taken to curb poaching.
7. Pabitora population is near habitat capacity. It will require monitoring to detect population trends and to restore the population in the event of a catastrophe.
8. According to the model, Dudhwa population should be supplemented periodically to sustain it for the next 100 years. The population is otherwise too small to grow and stabilize on its own.

Protected Area Management

9. The P.A. Management Group suggested that Rhino reintroduction may be considered in potential areas of Assam State viz: Laokhowa WLS, Burachapori Reserve Forest, Kochmara Reserve Forest. Kuruwa Reserve Forest, Disangmukh area and some areas of Uttar Pradesh and West Bengal in former range after evaluation of habitat suitability index for reintroduction.
10. The genetic continuity of rhino bearing areas such as Kaziranga, Orang and Laokhowa can be enhanced by expanding existing protected area and building of corridors to facilitate natural migration of individuals from one protected area to another.
11. As flood is the major adverse factor in rhino habitats, raising more artificial high-grounds for providing shelter to flood affected rhinos may be done.

12. In small areas which have small populations, translocation of compatible breeding stock from one area to another to increase the genetic variability and raise the recovery rate of the population may be done with a careful view that amelioration of degraded habitat and elimination of adverse factors (such as grazing) have been achieved.
13. Monitoring of habitat and population in rhino bearing areas should be done on a two year basis using satellite imageries of the areas for assessment of suitability of habitat and undertaking census of rhino population at regular intervals in order to classify them into age and sex classes.
14. Research—both theoretical and applied—should be undertaken to improve management, to shed light on the behaviour and biology of the species and assist in assuring its long-term survival.

Trade

15. Coordination between the 10-12 departments dealing with enforcement of law concerning rhino poaching and trade in India needs to be strengthened so that perception of the effectiveness of enforcement agencies as well as actual enforcement is strengthened.
16. Systems of intelligence gathering and informers have been demonstrated to be dramatically more effective than other strategies for prevention and capture of poachers in other rhino countries. Measures such as well-published and well paid reward schemes, developing an elite group of forest people trained in combating poaching, and systematic involvement of other agencies besides wildlife (police, revenue) should be taken up.
17. Effective intelligence networks are badly required along porous borders (which greatly encourage poaching) between India and other countries.
18. Investigation of rhino poaching/smuggling cases should be entrusted to the specialised agencies, working on a national level (e.g. C.B.I. and I.B. in India) so that the whole group of poachers/smugglers who are seldom confined to a single state can be exposed and prosecuted; the agencies should have access to INTERPOL to follow up a case across national boundaries.

Human Impact

19. The Human Impact Working Group identified areas of threat from human impact in terms of human **population** growth—fertility, mortality, in-migration from other areas, patterns of dependency, changes in attitude to rhino and the reserve, and political and civil unrest. The greatest threat may be from the trend over the last two decades of percentage of the growing population to be increasingly land poor and therefore dependency if rhino and its habitat are to be protected.

Education, Training And Public Awareness

20. The attitudes toward rhinoceros and its reserves often meets with animosity due to crop damage by rhinos straying out of their reserve and to the imposition of protection on forest areas used by local people. Programmes providing compensation for crop damage and alternate strategy for use of the forest need to be developed.
21. The Workshop noted the steps taken by the Forest Department of West Bengal to establish participatory management mechanism in Jaldapara. The

development of such programmes is essential in areas where use of p.a resources must be made compatible with conservation objectives.

22. Training in interaction with local people, as well as wildlife and handling of arms must be given to forest personnel in rhino areas.

23. Education programmes (with the Forest Department as a special advocate to improve education in general for local people around the reserves) along with extension and interpretation programmes need to be organised. Such programmes could integrate with Ecotourism programmes to insure benefits accruing for both animal and man in the reserves.

Captive Breeding

24. The zoos that have had breeding successes should be given priority when pairing or supplying animals.

25. Mates should be provided to proven breeders in different zoos so that maximum breeding potential is realised.

26. The use of Guwhati Zoo as orphanage for young rhinos stranded during flood has affected the management of the other rhinos in the zoo and should be curtailed. The orphanage should be attached with the Kaziranaga National Park or other rhino rearing area where facilities could be established to rear young animals. If surplus females are available from the orphanage, they may be kept for the ex situ breeding programme while surplus males could be used for re-introduction research.

27. A feasibility study should be undertaken to determine if indeed reintroduction of captive born rhinos into the wild is a viable possibility and what captive management activities should be undertaken to ensure a successful project. This could be done in consultation with the Reintroduction Specialist Group, SSC, IUCN.

28. All data related with each individual, namely date of birth, date of any acquisition, transfer, date of death and cause of death should be sent to the National Studbook Keeper (Kanpur Zoo), the Species Coordinator (Addl. I.G., Wildlife), and Central Zoo Authority. The National Studbook Keeper should take all the responsibility to send all information to the International Studbook Keeper.

29. All the zoos that maintain the species should have educational materials available to the visitors and they can be in the form of signage, brochures, or pamphlets in the light of conserving the species.

Health And Disease

30. Suitable veterinary units should be established in all protected areas through which immunisation of domestic livestock in fringe areas and monitoring health of rhino population can be done.

31. Every zoo that maintains this species should perform post-mortem for each and every animal and the results should be made available to the Regional Studbook Keeper, Species Coordinator and Central Zoo Authority. The post-mortem results may be maintained in accordance with the format as already laid down in the guidelines by the Central Zoo Authority. Additional required information may be added to the existing format of C.Z.A.

32 The disease which can be prevented by periodical testing and vaccination like rinderpest, haemorrhagic septicaemia, and tuberculosis should be taken into consideration for routine prophylactic measures. The treatment records should be kept properly.

Translocation and Reintroduction

33. Objectives of Translocation for rhinoceros as defined by the Workshop are : to strengthen non-viable populations to become permanent, self-perpetuating populations; to establish new populations in former range, to maintain high heterozygosity in the population; to distribute populations over large range to prevent loss due to catastrophic event.

34. The Workshop laid down basic criteria for identification of recipient areas: recipient area should have a carrying capacity of 100 rhinos; area should have strictest possible legal protection status (e.g. National Park Sanctuary); area must have high quality law enforcement and no significant poaching case in recent years; area should have a management plan and instructure for carrying it out; area should be subject of detailed study including expertise in the following areas: ecology, botany, management, law enforcement, sociology, and captive management.

In the case of a location which currently has no rhinos, an initial reintroduction should be minimum of 10 animals of an age to controduct reproductively in the new area as soon as possible. As soon as breeding is successfully established, further supplementation can be considered.

35. The Workshop established priorities for animals to be selected for translocation: they should be sought from isolated or doomed areas where their future existence is doubtful, first priority going to areas which have no legal protection status and next priority going to surplus animals in well stocked areas.

36. Translocated animals should be systematically monitored including their effect on the habitat and until they have established equilibrium with the new surroundings and are breeding successfully.

Funding

37. Funding proposals should be submitted to international aid agencies as per broad subject headings which have been drawn up by the working group, keeping in mind the management requirements of the rhino population of different sizes in India.

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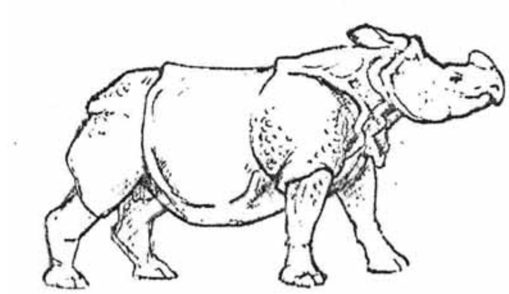
Section II

Working Group reports



Report of the Modeling group

Members: R.Sukumar (Facilitator), Robert C. Lacy, J.A.Santosh, S.Molur, A. Tajuddin,R.K.Sinha, U.S.Seal

The exercise of this group involved running simulations using VORTEX to forecast
Population status for 100 years. Simulations were divided into two different categories- First, models with hypothetical parameter values (but within observed/acceptable ranges) were run using various permutations. School, models simulating specific parameters for different existing populations were developed.

Below is a brief description of the parameters used in the simulations.

Breeding systems and reproductive rates
The Indian / Nepalese Rhino is a polygynous species. Age at first breeding for the male was taken to be 10 years and for females it was varied between 7 and 10 years.

Population exists in varying sizes and densities, most often in isolated fragments. Reproduction was modelled as a density-dependent factor with the proportion of breeding females as function of density. Reduction in proportion of breeding females occurred only at densities reaching 80% of the carrying capacity and there was no Allee effect included.

Inter-calving interval was varied between 3.3 and 5 years resulting in birth probabilities of 0.30 and 0.20 per adult female per year respectively. Litter size was taken to be 1 in all cases.

Maximum longevity
A maximum longevity of 40 years was used for males and females.

Sex ratio at birth
A 1:1 ration of male and female calves at birth was assumed, although a marginally male biased sex ratio is likely in a polygynous mammal.

Correlation between EV (reproduction) and EV (survival):
No correlation between EV (reproduction) and EV(survival) was included.

Mortalities

Mortality rates were adjusted in order to vary the deterministic population growth rates(r) for the different scenarios. Male mortalities were taken to be slightly higher than female mortalities as observed in polygynous species and to account for adult male to female ratio.

Population of death for females (per year) used were:
Ages 0 to 1:12%; ages 1-7:7% age 7 and above: 6%

Probabilities of death for males (per year) used were:
Ages 0 to 1:12% ages 1 to 10.8%; age 10 and above: 7%

Environment stochasticity
Environment stochasticity is modeled as variation in birth and death probabilities by sampling binomial distributions. Standard deviation in mortalities was fixed at 30% of the mean.

Carrying capacity
Constraints in available habitat appear to be a serious constrains to growth for almost all existing populations. The basic generalized models were run under two scenarios for carrying capacity. The first scenario considered the carrying capacity to be 20% higher than the initial population size and the second assumed a larger carrying capacity of 240 animals.

For the simulations of the specific populations, carrying capacities were set at estimates for the individual populations based upon discussions with personal connected with the areas. Scenarios that considered possible extensions of the existing protected areas were also simulated.

Inbreeding depression
There are no data on inbreeding depression in rhinos. We therefore ran the simulations with no inbreeding with inbreeding depression using a heterosis model with a level of 3.14 lethal equivalents which represents the mean value for 40 mammalian species studied (Ralls et al.),

Catastrophes
Two types of catastrophes were modeled to reflect minimal effects of a serious flood and of Poaching. The probability of flood was assumed to be 10% with no effect on reproduction and a 5% decrease in survivorship. The probability of poaching was taken to be 10% with two different degrees of severity. Low poaching assumed a 5% effects on survivorship and no effect on reproduction, while the high poaching scenario considered, a 5% effect on survivorship and a 50%effect on reproduction due to disruptions in social structure as a result of removal of individuals.

Basic scenario
Model with different parameters combinations were run to give scenarios. (Mortalities were adjusted, to yield intrinsic growth rate values of 0.0.02(2& per year), 0.04(4% per year) Starting population sizes were 10, 25, 50,100 and 200 rhinos in an assumed stable age distribution. Carrying capacities in one group of models were 20% above initial population sizes and were 240 rhinos in another. All combinations were run with and without inbreeding effects.

Results

Simulations of basic scenario

Effect of population growth rate
With minimal populations growth (r=.003), the simulated populations experienced an extinction rate of 0-6.6% if the initial population size was greater than 50. Population of 100 Or 200 initial rhinos also had stochastic growth rates close to the predicted deterministic growth, and SD (of stochastic r) was small. Both indicate relative demographic stability. Genetic stability in these populations was evidenced by the gene diversity remaining above 90%. Populations started with 50 rhinos experienced under 10% extinctions, but become weakly inbred (11<90%) over 100 years. Smaller populations often went extant when the population growth rate was set near zero. They contained few animals even when, extant; and they become highly inbred (H<70%).

Under moderate population growth (deterministic r =.02), populations started with 50 or more rhino almost always survived, and retained more than 85% of initial heterozygosis. Probabilities of extinction of the smallest populations (starting with 10 or 25 rhinos) decreased, but were not eliminated, under high population growth rate (4%).

Effect of final carrying capacity
Models with large carrying capacities (K=240) had lower probabilities of extinction than when carrying capacity was only 20% above the above the starting population size. Under the strongest population growth(r=.04) populations started with just 25 rhinos were demographically and genetically capacity models retained more genetic variation especially when the initial size was small and the population growth rate was large.

Effect of intensity of poaching
When poaching was imposed on the basic models, with populations of less than 50 individuals were almost always unstable. Even with large initial population sizes. Large carrying capacities, and strong population growth (in the absence of poaching), extinctions were frequent in most scenarios. Final population's sizes of remaining populations were small, and the populations become highly inbred. Only the largest populations with the strongest population's growth could sustain the higher level of poaching without entering population decline. Higher levels of poaching have occurred in some population for several years. Those higher levels of poaching cannot be sustained under any plausible scenario for rhino populations biology.

Effect of inbreeding depression
It is not know to what extent inbreeding might depress survival or fecundity of the Indian Nepalese rhino. Because some of the populations are small, however, inbreeding might be expected to occur in future is not rapid and carrying capacities are large, Inbreeding depression moderately increased probabilities of extinction and depressed population sizes of surviving populations at median level of 3.14 LE repeated for captive population are 40 mammalian species. The impact of inbreeding was most apparent at the smallest population sizes, as

expected since only those populations became significantly inbred during 100 year simulations. Although inbreeding inbred were unstable demographically and would not be expected to be viable over 100 years even inbreeding has no further impact on population stability. Many mammals suffer a greater reduction in survival than modeled here when inbred, and most mammal species studied also show a decline in decline in fecundity when inbred. Therefore, the impact of inbreeding on the viability of the rhino populations may well be greater than in our models.

Simulations of individual's populations

Five rhino populations in India are small (range 15 to 97), excepting Kaziranga National Park estimated population in 1993 of 1164 rhinos and may need intensive management to Prevent stochastic extinctions. The result of the simulations for individual populations, Based on available information and judgment of demographic and habit parameters are summarized below.

1. Gorumara

This is a small isolated area of 9 sq .km with a population of 15 rhinos. The rhino numbers have not increased much during the past few decades, indicating that the population is very close to the carrying (estimated at 20), and that its growth rate is not more than 1% per year (r</=-0.01). This is potentially subject to severe inbreeding.

Four simulations were run for this population incorporating inbreeding depression under conditions yielding 'r' values of 0.0.01, 0.02 and 0.04. As the results in table 5 indicate, the population have a very high probability of extinction when r=0 or 0.01. Even with r= 0.02 there is still a 15% probability of extinction within 100 years. These populations would also become severely inbred with only 69.5 % of heterozygosis retained after 100 years.

Any increase in mortality due to severe catastrophe (flood, disease) also increased the chance of extinction. However, if probabilities of death could be significantly reduced
(which is very unlikely) , and the intrinsic growth rate simulated to 0.04, the population could have a greater than98% probability of survival for 100 years, even with an initial carrying capacity of 20 (decreasing at < 3% in 100 years).

2. Jaldapara

Jaldapara, with an area of extent of 216 sq. km. is of better size to hold a viable populations of rhinos (k=10). The base simulation begins with the present population of 34 rhinos assumed to be at stable age distribution. Carrying capacity was set at 100 with an annual decrease of 1% for 20 years. A 10% probability of a catastrophe (such as anthrax disease) Killing 2 % of individuals, and a 50% probability of another catastrophe (poaching) killing 55 of individual and depressing reproduction by 10 % were specified in all runs. Simulations were carried out with and without inbreeding depression.

The result (table 5) show that if intrinsic population growth r=0.02(2% per year) or higher the population can still absorb the catastrophes and have a 99 % probability of survival. With r=0, the probability of survival is only 81 % (with inbreeding) and 86 % (without inbreeding).

Habit changes is jaldapara, in particular the invasion of grasslands by forest, may however change the picture substantially.

3. Other populations:

The other populations of rhinos in Kaziranga, Dudhwa, Pabitora, Manas and Orang were modeled under the general scenario and the effect on the respective population sizes. The Kaziranga population being the largest with 1100+rhinos faces no threat of extinction or loss of heterozygosis in the next 100 years. His situation could however deteriorate if the present trend of poaching continues.

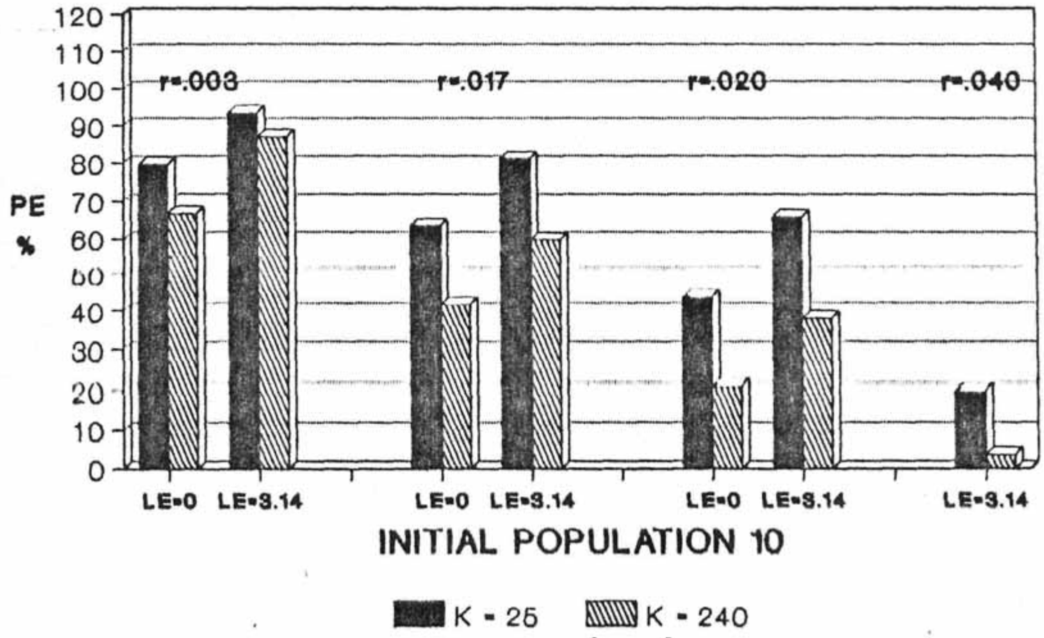
Dudhwa population is too small to sustain itself in the long run. The results (table 1-4) show that the population with initial size of 10 has a high probability of extinction.—90% probability of extinction with an intrinsic growth rate of .003 and 20% probability of extinction at intrinsic growth rate pf 0.04. The populations can survives only with periodic supplementation which would also infuse enough genes to avoid inbreeding (table 7).

The predictions for Orang and Pabitora can be deduced form the tables 1-4. These populations have more than 50 individuals and according to the model these populations are sufficiently big to survive big to survive for the next 100 years provided poaching is reduced to less than 2%. For Pabitora with a population size of 56, the model showed that the heterozygosis retained by the end of the 100 years a maximum of 87% when the intrinsic growth rate is fixed at 0.04 (table 4). In the case of 0 growth rate, the amount of heterozygosis retained is just 80% (table 1).

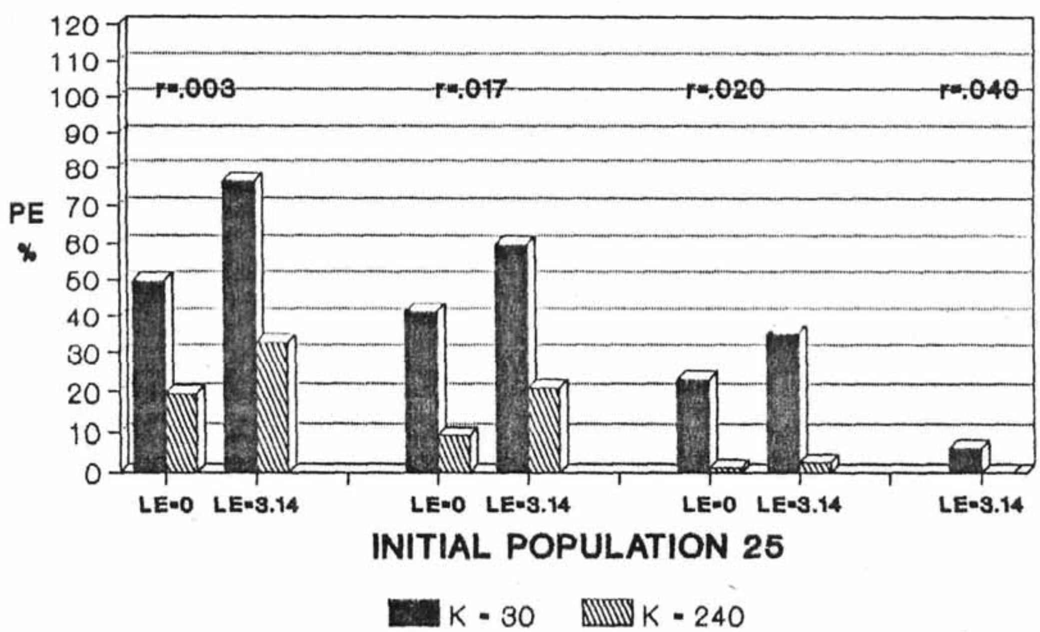
Recommendations

1. If a management goal of 70 rhinos for jaldapara is considered, the present population may take 15-25 years to grow to this level if no additional poaching occurs. This size population could be a viable sub population in a metapopulation management strategy.
2. According to the modeling exercise, the jaldapara population at the present status and growth rate cannot sustain an annual poaching rate of even 2% or one rhino per year.
3. At the present rate of growth and the initial number of animals, the model showed the Jaldapara population to be inbred (heterozygosity retained may be around 75%). Supplementation of fresh lines into this population at intervals will increase the gene diversity and the viability of the population.
4. The Gorumara population will require intensive management and frequent supplementation to survive demographic, stochastic and potential inbreeding depressions from genetic drift.
5. A metapopulation management strategy needs to be developed taking into account the population trends in each area, the current and expected habitat availability and quality and the levels of which poaching can be controlled. Given the small area available, it may be that the Gorumara populations will not able to recover if poaching can not be reduced.
6. The estimated total rhino numbers is 1400-1500 in 6 populations with the Kaziranga population comprising 1100+ of the total. The modeling shows that four of the five smaller populations (except Gorumara) are potentially viable n 100 years projections if poaching can be controlled. Poaching is an important factor in the nonviability of populations. Stringent steps must be taken to curb poaching.
7. Pabitora population is near habitat capacity. It will require monitoring to detect population trends and top restore the population in the event of a catastrophe.
8. According to the model, Dudhwa population should be supplemented periodically to sustain it for the next 100 years. The population is otherwise too small to grow and stabilize on its own.

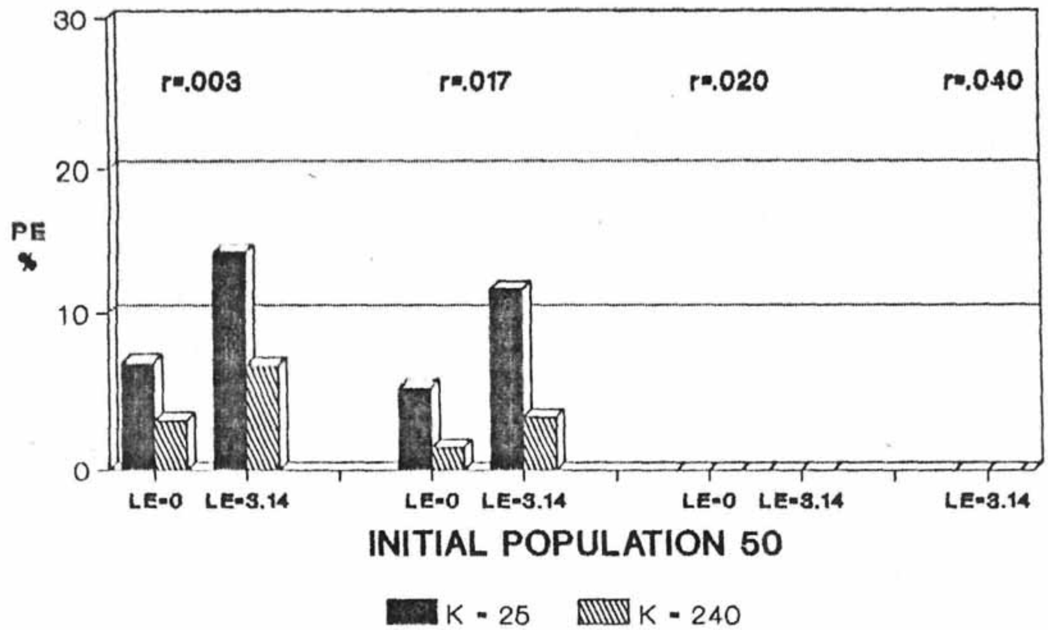
Graph 1. General runs. Probability of extinction for populations of initial size 10 at K of 20% more and at 240, lethal equivalents of 0 and 3.14 and different growth rates.



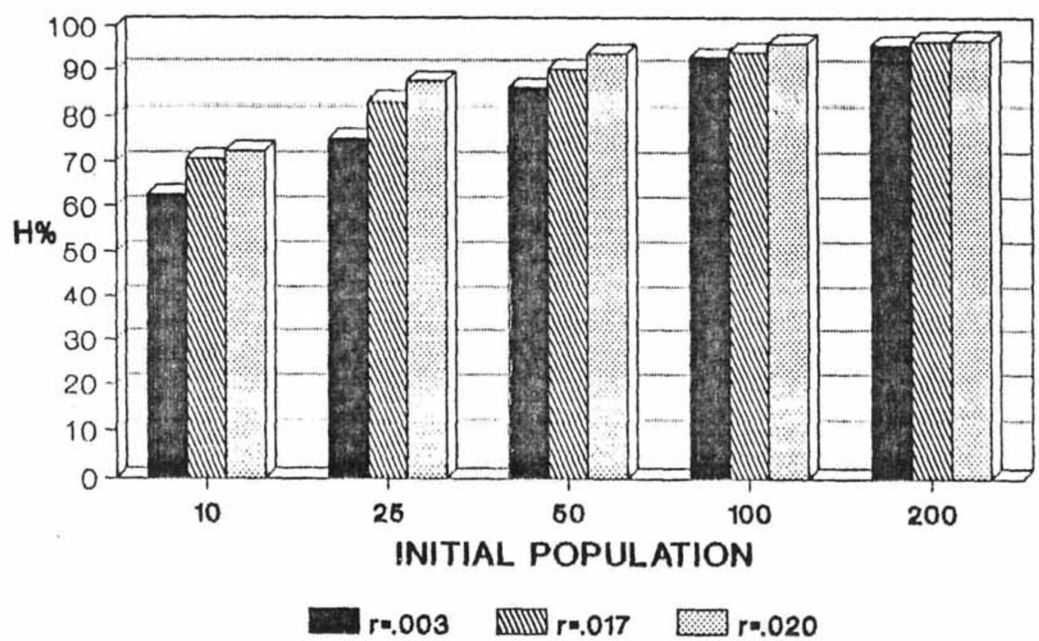
Graph 2. General runs. Probability of extinction for populations of initial size 25 at K of 20% more and at 240, lethal equivalents of 0 and 3.14 and different growth rates.



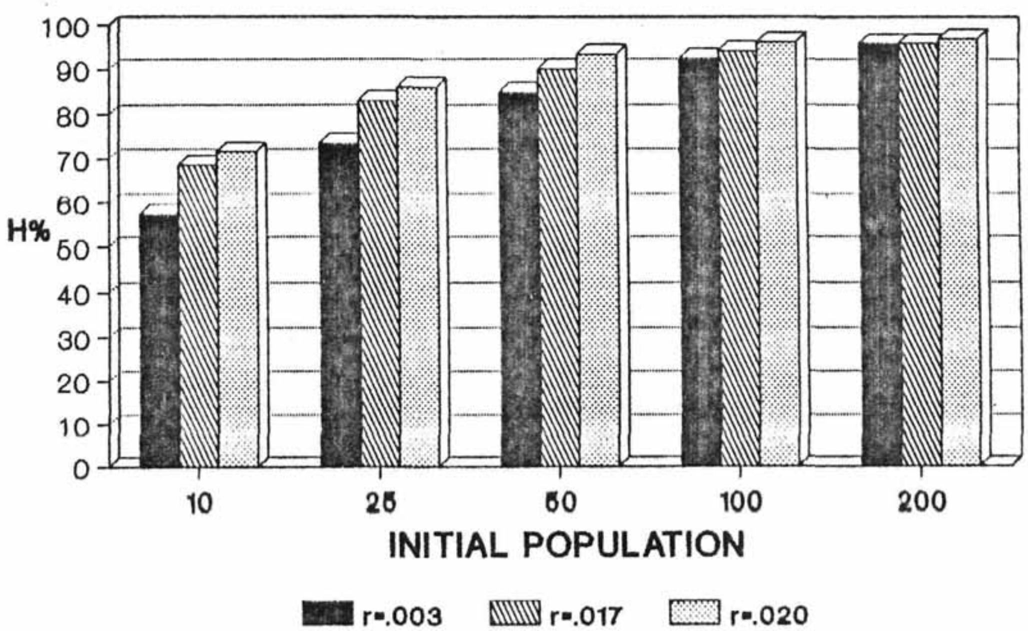
Graph 3. General runs. Probability of extinction for populations of initial size 50 at K of 20% more and at 240, lethal equivalents of 0 and 3.14 and different growth rates.



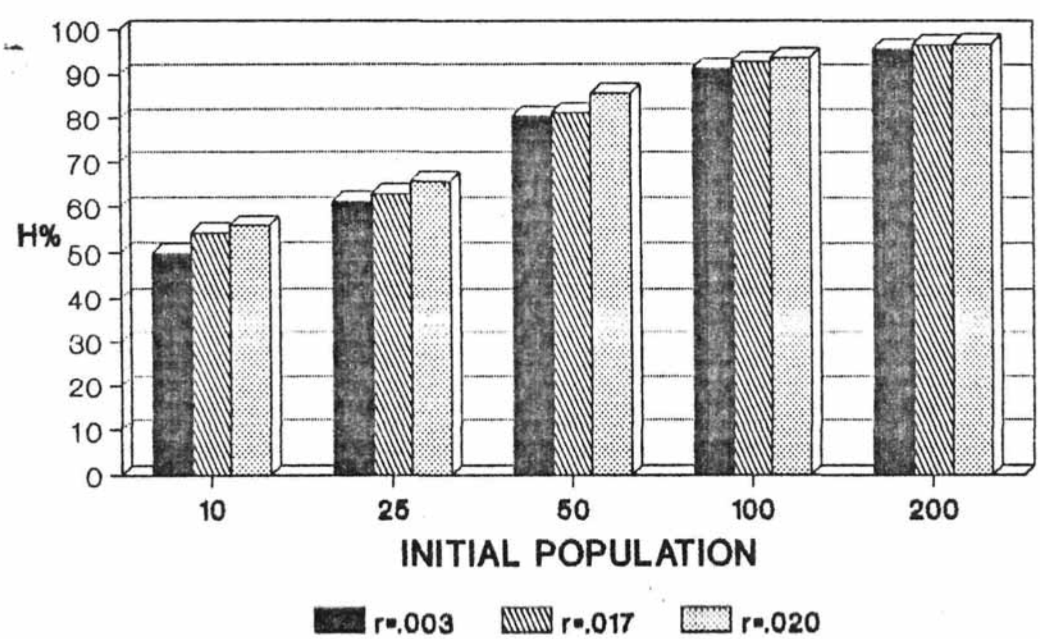
Graph 4. General runs. Percent heterozygosity retained at 100 years for different populations at K of 240, lethal equivalents of 0 and different growth rates.



Graph 5. General runs. Percent heterozygosity retained at 100 years for different populations at K of 240, lethal equivalents of 3.14 and different growth rates.



Graph 6. General runs. Percent heterozygosity retained at 100 years for different populations at K of 20%>N, lethal equivalents of 0 and different growth rates.



Graph 7. General runs. Percent heterozygosity retained at 100 years for different populations at K of 20%>N, lethal equivalents of 3.14 and different growth rates.

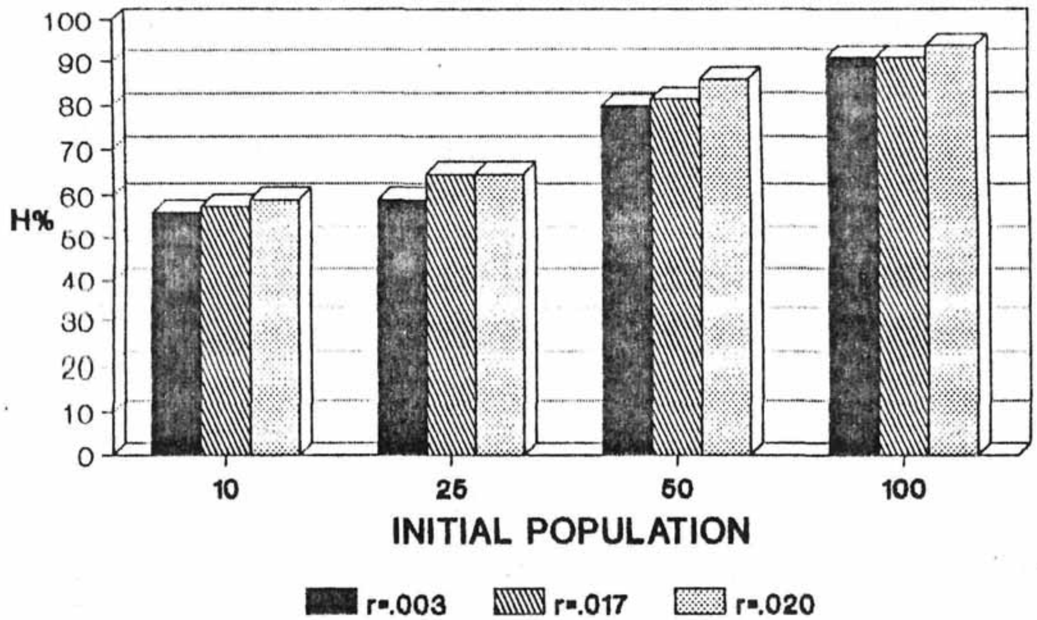


Table 1.

FILE NAME	INI. POP.	K	RESULTS AT 100 YEARS					POP. GROWTH	
			PE %	N	SD	11%	TE	STOCH	SD
GENERAL RUNS: Deter r = .003; L.E. = 3.14; Catas. = 10%, Sur= .95, Rep =1. Female Mortality / Male Mortality Inf: 12.00 (4.00 SD); 12.00 (4.00 SD) Juv: 7.00 (2.33 SD); 8.00 (2.67 SD) Ad: 6.00 (2.00 SD); 3.00 (1.00 SD)									
ROKI.1	10	25	93.6	5	3.07	56.1	44.5	-.0280	.1589
ROKI.2	25	30	76.4	8	4.32	59.0	75.0	-.0217	.1344
ROKI.3	50	60	14.2	23	11.68	79.7	85.0	-.0093	.0885
ROKI.4	100	120	.6	60	23.37	90.9	98.5	-.0044	.0616
ROKI.5	200	240	0	144	40.52	95.9	-	-.0022	.0505
ROKI.6	10	240	87.2	11	11.75	57.5	47.5	-.0250	.1522
ROKI.7	25	240	32.8	20	16.60	73.6	71.0	-.0127	.1051
ROKI.8	50	240	6.6	42	30.08	85.0	82.0	-.0062	.0771
ROKI.9	100	240	.4	94	48,16	92.5	87.5	-.0022	.0580
GENERAL RUNS: Deter r = .003; L.E. = 0; Catas. = 10%, Sur= .95, Rep= 1. Female Mortality / Male Mortality Inf: 12.00 (4.00 SD); 12.00 (4.00 SD) Juv: 7.00(2.33 SD); 8.00(2.67SD) Ad: 6.00 (2.00 SD); 3.00 (1.00 SD)									
ROK.1	10	25	79.8	9	4.70	49.8	46	-.0152	.1532
ROK.2	25	30	49.8	11	5.30	61.3	63	-.0092	.1265
ROK.3	50	60	6.8	30	12.43	80.5	79.5	-.0033	.0820
ROK.4	100	120	.2	71	22.71	91.3	81	-.0013	.0602
ROK.5	200	240	0	152	42.41	95.8	-	-.0016	.0509
ROK.6	10	240	66.8	27	21.44	62,6	45	-.0111	.1377
ROK.7	25	240	19.4	38	31.79	75.3	66.5	-.0044	.0994
ROK.8	50	240	3.4	65	42.11	86.0	78	-.0006	.0730
R0K.9	100	240	0	116	52.24	92.9	-	-.0004	.0566

Table 2.

FILE NAME	INI. POP.	K	RESULTS AT 100 YEARS					POP. GROWTH	
			PE%	N	SD	H%	TE	STOCH r	SD
GENERAL RUNS: Deter r = .017; L.E. = 3.14; Catas.= 10%, Sur = .95,Rep= 1. Female Mortality Male Mortality Inf: 9.00 (3.00 SD); 9.00 (3.00 SD) Juv: Age 1- 4 = 2.00 (.67 SD); Age 1- 4 = 2.00 (.67 SD) Age4-7 = 3.00(1.00SD); Age4-10 = 4.00 (1.33SD Ad: 3.00(L00SD); 4.00 (1.33 SD)									
2R4KI.1	10	25	81.2	8	4.38	57.5	51	-.0125	.1726
2R4KI.2	25	30	59.8	10	6.06	64.6	64.5	-.0093	.1572
2R4KI.3	50	60	11.6	29	14.86	81.2	78	.0003	.1266
2R4KI.4	100	120	2.4	70	30.02	90.8	82.5	.0054	.1125
2R4KI.5	200	240	.4	155	52.90	95.7	89.5	.0074	.1062
2R4KI.6	10	240	59.8	35	37.62	68.6	48	-.0087	.1594
2R4KI.7	25	240	21.0	81	66.78	83.1	59.5	.0011	.1303
2R4K1.8	50	240	3.6	121	68.86	90.0	70.5	.0074	.1131
2R4KI.9	100	240	1.2	141	61.33	94.1	89.5	.0075	.1094
GENERAL RUNS: Deter r = .017; L.E. = 0;Catas. = 10%, Sur= .95, Rep = 1. Female Mortality Male Mortality Inf: 9.00 (3.00 SD); 9.00 (3.00 SD) Juv: Age 1-4 = 2.00(.67 SD); Age 1-4 = 2.00(.67 SD) Age 4 - 7 = 3.00 (1.00 SD); Age 4 -10 = 4.00 (1.33 SD) Ad: 3.00 (1.00 SD); 4.00 (1.33 SD)									
2R4K.1	10	25	63.6	11	5.31	54.3	47	-.0009	.1663
2R4K.2	25	30	41.4	14	6.15	62.9	59	.0019	.1524
2R4K.3	50	60	5.4	33	14.20	81.2	74.5	.0066	.1249
2R4K.4	100	120	.6	76	28.08	90.8	84.5	.0075	.1131
2R4K.5	200	240	.4	160	52.90	95.7	60	.0086	.1068
2R4K.6	10	240	41.6	68	60.20	70.7	42	.0037	.1490
2R4K.7	25	240	9.2	100	68:66	83.1	54	.0089	.1249
2R4K.8	50	240	1.6	131	64.78	90.2	61	.0100	.1137

2R4K.9	100	240	0	155	54.85	94.1	-	.0101	.1080

Table 3.

FILE NAME	INI. POP.	K	RESULTS AT 100 YEARS					POP. GROWTH	
			PE%	N	SD	H%	TE	STOCHr	SD
GENERAL RUNS: Deter r= ,020; L.E. = 3.14; Catas. = 10%, Sur= .95, Rep= 1. Female Mortality Male Mortality Inf: 12.00 (4.00 SD); 12.00 (4.00 SD) Juv: Age 1-4 = 4.00(1.33 SD); Age 1-4= 4.00(1.33 SD) Age 4-7 = 5.00 (1.67 SD); Age 4 -10 = 6.00 (2.00 SD) Ad: 4.70 (1.60 SD); 6.00 (2.00 SD)									
R2KI.1	10	25	66.0	8	4.21	56.9	58	-.0069	.1319
R2KI.2	25	30	35.4	12	5.53	64.6	71.5	-.0013	.1092
R2KI.3	50	60	.6	39	10.43	85.8	83	.0093	.0657
R2KI.4	100	120	0	97	9.49	93.8	-	.0114	.0506
R2KI.5	200	240	0.	203	15.00	96.9	-	.0117	.0437
R2KI.6	10	240	38.0	34	32.99	71.6	58.5	-0003	.1109
R2KI.7	25	240	2.6	102	58.13	86.1	71	.0111	.0075
R2KI.8	50	240	0	179	44.01	93.4		.0143	.0513
R2KI.9	100	240	0	202	15.56	96.2	-	.0137	.0455
GENERAL RUNS: Deter r = .020; L.E. = 0; Catas. = 10%, Sur= .95, Rep= 1. Female Mortality Male Mortality Inf: 12.00 (4.00 SD); 12.00 (4.00 SD) Juv: Age 1-4 = 4.00(1.33 SD); Age 1-4= 4.00 (1.33 SD) Age 4-7 = 5.00 (1.67 SD); Age 4 -10 = 6.00 (2.00 SD) Ad: 4.70 (1.60 SD); 6.00(2.00SD)									
R2K.1	10	25	43.8	12	4.91	55.9	55.5	.0066	.1242
R2K.2	25	30	23.2	16	5.61	65.7	64	.0095	.1024
R2K.3	50	60	0	44	8.07	85.7	-	.0143	.0648
R2K.4	100	120	0	99	8.87	93.7	-	.0138	.0506
R2K.5	200	240	0	205	12.66	96.9	-	.0129	.0439
R2K.6	10	240	21.2	37	56.07	72.4	46	.0130	.0980
R2K.7	25	240	1.2	85	56.49	87.5	70.5	.0175	.0632
R2K.8	50	240	0	154	28.42	93.7	-	.0172	.0505

R2K.9	100	240	0	201	13.15	96.2	-	.0153	.0454

Table. 4.

FILE NAME	INT. POP.	K	RESULTS AT 100 YEARS					POP. GROWTH	
			PE%	N	SD	H.%	TE	STOCK r	SD
GENERAL RUNS: Deter r= .040; L.E. = 3.14; Catas. = 10%, Sur = .95, Rep = 1. Femsle Mortality Male Mortality Inf: 9.00 (3.00 SD); , 9.00 (3.00 SD) Juv: Age 1-4 = 2.00 (.67 SD); Age 1-4 = 2.00 (.67 SD) Age 4-7 = 3.00 (1.00 SD); Age 4-10= 4.00 (1.33 SD) Ad: 3.00 (1.00 SD); 4.00 (1.33 SD)									
R4KI.1	10	25	19.8	12	4.63	62.2	60.5	.0175	.1012
R4KI.2	25	30	6.2	17	5.19	71.5	63.5	.0226	.0846
R4KI.3	50	60	0	48	4.90	87.9	-	.0286	.0565
R4KT.4	100	120	0	92	4.91	92.3	-	.0289	.0594
R4K1.5	200	240	0	212	7.18	97.1	-	.0298	.0398
R4KI.6	10	240	3.6	151	66.49	82.1	47.5	.0259	.0704
R4KI.7	25	240	0	212	8.28	92.7	-	.0350	.0482
R4KI.8	50	240	0	212	6.64	95.6	-	.0339	.0249
R4KL.9	100	240	0	212	6.86	96.7	-	.0326	.0407

Table 5.

FILE NAME	DET r	RESULTS AT 100 YEARS				TE	POP. GROWTH	
		PE%	N	SD	H %		STOCH r	SD
GORUMARA: N= 15; K = 20; L.E. = 3.14; Catas. = 10%, Sur = .95, Rep = 1.								
GO.10	0	65.2	7	3.94	62.7	66	-.0179	.1210
GO.O	0	40.2	11	4.71	64.8	64	-.0090	.1121
GO.ll	.009	34.2	10	4.56	67.3	70.5	-.0076	.1046
GO.l	.009	24.6	13	4.73	66.8	64.5	-.0017	.1013
GO.12	. .021	15.8	12	4.25	69.5	71.5	.0012	.0955
GO.2	.021	10.4	15	4.06	68.3	69.5	.0071	.0944
GO.14	.040	1.4	16	3.46	72.5	61.5	.0174	.0822
G0.4	.040	.8	17	2.11	71.6	69	.0245	.0816
GORUMARA: N= 15; K = 20; L.E. = 0; Catas. = 10%, Sur = .95, Rep =1.								

Table 6.

FILE NAME	L.E.	DETr	RESULTS AT 100 YEARS				TE	POP. GROWTH	
			PE%	N	SD	H%		STOCH r	SD
JALDAPARA:N = 34;K= 100; Female Fertility Age = 10; Male Fertility Age=12; Catas: Rep= 90; Sur- .94; 50% Female Mortality Male Mortality Inf: 5.00 (1.67SD); 5.00(1.67SD) Juv: 3.00 (1.00 SD); 3.00 (1.00 SD) age 1-8; 2.00 (.67 SD) age 9-10; Ad: 2.00 (.67 SD); 3.00 (1.00 SD)									
JAL.I0	3.14	0	18.6	25	17.79	80.8	76.5	-.0097	.1026
JAL.0	0	0	13.8	32	20.07	81.3	76	-.0061	.1032
JALDAPARA: N = 34; K = 100; Female Fertility Age=7; Male Fertility Age= 10; Catas: Rep = .90;Sur=.95;50% Female Mortality Male Mortality Inf: 4.00 (1.33 SD); 5.00 (1.67 SD) Juv: 2.00 (.67 SD); 3.00 (1.00 SD) Ad: 2.00 (.67 SD); 3.00 (1.00 SD)									
JAL.I2	3.14	.020	0	60	18.08	88.4	75	.0113	.0912
JAL.2	0	.020	0	66	15.10	88.5	-	.0152	.0924
JALDAPARA: N = 34; K= 100; Female Fertility Age = 7; Male Fertility Age=10; Catas: Rep = .90; Sur = .97; 50% Female Mortality Male Mortality Inf: 4.00 (1.33 SD); 5.00 (1.67 SD) Juv: 1.00 (.33 SD); 2.00 (.67 SD) Ad: 1.00 (.33 SD); 1.00 (.33 SD)									
JAL.I4	3.14	.040	0	75	5.57	92.0	-	.0311	.0805
JAL.4	0	.040	0	75	5.00	91.8	-	.0335	.0825
JALDAPARA: N = 34; K = 100; Female Fertility Age = 6; Male Fertility Age = 10; Catas: Rep= .97; Sur = .97; 50% Female Mortality Male Mortality Inf: 4.00 (1.33 SD); 5.00 (1.67 SD) Juv: 1.00(.33 SD); 2.00(.67SD) Ad: .60(.20SD); 1.00 (.33 SD)									
JAL.18	3.14	.060	0	77	3.93	91.2	-	.0504	.0853
JAL.8	0	.060	0	77	3.85	90.7	-	.0538	.0880

Table 7.

<table>
<tr><th rowspan="2">FILE NAME</th><th rowspan="2">DET r</th><th colspan="4">RESULTS AT 100 YEARS</th><th rowspan="2">TE</th><th colspan="2">POP. GROWTH</th></tr>
<tr><th>PE%</th><th>N</th><th>SD</th><th>H%</th><th>STOCH</th><th>SD</th></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25; L.E. = 3.14; Catas. = 10%, Sur= .95, Rep= 1, Female Fertility Age = 8; Male Fertility Age =10
Female Mortality Male Mortality
Inf: 15.00 (5.00 SD); 15.00 (5.00 SD)
Juv: 3.00 (1.00 SD); 4.00 (1.30 SD) age 1-5
Ad: 3.00 (1.00 SD); 5.00(1.70 SD)</td></tr>
<tr><td>DUR1</td><td>.008</td><td>46.8</td><td>10</td><td>5.71</td><td>65.5</td><td>60.5</td><td>-.0080</td><td>.1233</td></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25; L.E. = 3.14; Catas. = 10%, Sur = . 95, Rep=l, Female Fertility Age= 8; Male Fertility Age=10
Female Mortality Male Mortality
Inf: 10.00 (3.33 SD); 10.00 (1.67 SD)
Juv: 2.50 (.67 SD); 3.00 (1.00 SD)
age 1-5;3.50(1.00)SD)age5-10
Ad: 2.50 (.67 SD); 3,50(1.0()SD)</td></tr>
<tr><td>DUR2</td><td>.028</td><td>11.0</td><td>17</td><td>5.67</td><td>71.8</td><td>68.5</td><td>.001</td><td>.1042</td></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25; L.E. = 3.14; Catas.= 10%, Sur= .95, Rep=l, Female Fertility Age = 8; Male Fertility Age=10
Female Mortality Male Mortality,
Inf: 10.00 (3.33 SD) 10.00 (1.67 SD)
Juv: 2.00 (.67 SD) 3.00 (1.00 SD)
Ad: 2.00 (.67 SD) 3.00 (1.00 SD)</td></tr>
<tr><td>DUR4</td><td>.045</td><td>.4</td><td>21</td><td>3.52</td><td>75.1</td><td>48.5</td><td>.0247</td><td>.0945</td></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25;L.E. = 3.14; Catas.= 10%, Sur = .95, Rep=l, Female Fertility Age = 8;Male Fertility Age=10,One 10 year Male added to population
Female Mortality Male Mortality
Inf: 15.00 (5.00 SD); 15.00 (4.00 SD)
Juv: 3.00(1.00SD); 4.00(1.30SD) age 1 -5
Ad: 3.00 (1.00 SD); 5.00 (1.70 SD)</td></tr>
<tr><td>DU1S1</td><td>.008</td><td>53.2</td><td>10</td><td>5.79</td><td>65.8</td><td>66</td><td>-.0105</td><td>.1241</td></tr>
<tr><td>DUR2K</td><td>.028</td><td>5.0</td><td>29</td><td>9.05'</td><td>78.0</td><td>54</td><td>.0137</td><td>.0958</td></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25; L.E. = 3.14; Catas. = 10%, Sur=.95, Rep=l, Female Fertility Age = 8; Male Fertility Age=10; 1 Male 10 years added; r=.l267 (.1060)
Female Mortality Male Mortality
Inf: 10.00 (3.33 SD); 10.00 (1.67 SD)
Juv: 2.50 (.67 SD); 3,00(1.00 SD)
age 1-5:3.50(1.00 SD)age5-10
Ad: 2.50 (.67 SD); 3.50 (1.00 SD)</td></tr>
<tr><td>DU2S1</td><td>.028</td><td>7.8</td><td>17</td><td>5.51</td><td>73.4</td><td>69.5</td><td>.0098</td><td>.1014</td></tr>
</table>

<table>
<tr><td rowspan="2">FILE NAME</td><td rowspan="2">DET r</td><td colspan="4">RESULTS AT 100 YEARS</td><td rowspan="2">TE</td><td colspan="2">POP. GROWTH</td></tr>
<tr><td>PE%</td><td>N</td><td>SD</td><td>H%</td><td>STOCH r</td><td>SD</td></tr>
<tr><td colspan="9">DUDHWA: N = 10; K = 25; L.E. = 3.14; Catas. = 10%, Sur = .95, Rep= 1, Female Fertility Age = 8; Male Fertility Age = 10; 2 Females of 8 yrs and 1 Male of 10 yrs added; r = .2732 (.0908)
Female Mortality Male Mortality
Inf: 10.00 (3.33 SD); 10.00 (1.67 SD)
Juv: 2.50 (.67 SD); 3.00 (1.00 SD)
age l-5;3.50 (1.00 SD)age 5-10
Ad: 2.50 (.67 SD); 3.50 (1.00 SD)</td></tr>
<tr><td>DUS12</td><td>.028</td><td>6.0</td><td>17</td><td>5.41</td><td>74.9</td><td>80.5</td><td>.0120</td><td>.1013</td></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25; L.E. = 3.14; Catas. = 10%, Sur = .95, Rep = 1, Female Fertility Age = 8; Male Fertility Age=10; 20 Females of 8 yrs and 1 Male of 10 yrs added 3 times in 5 yrs.; r = .2230 (.1021)
Female Mortality Male Mortality
Inf: 10.00 (3.33 SD); 10.00(1.67 SD)
Juv: 2.50 (.67 SD); 3.00 (1.00 SD)
age l-5;3.50(1.00SD)age5-10
Ad: 2.50 (.67 SD); 3.50 (1.00 SD)</td></tr>
<tr><td>DUS24</td><td>.028</td><td>4.0</td><td>18</td><td>5.27</td><td>75.0</td><td>79</td><td>.0120</td><td>.1018</td></tr>
<tr><td colspan="9">DUDHWA: N= 10; K = 25; L.E. = 3.14; Catas. = 10%, Sur = .95, Rep= 1, Female Fertility Age = 8; Male Fertility Age =10; 2 Females of 8 yrs and 1 Male of 10 yrs added; r = .2727 (.0888)
Female Mortality Male Mortality
Inf: 10.00 (3.33 SD); 10.00 (1.67 SD)
Juv: 2.50 (.67 SD); 3.00 (1.00 SD)
agel-5;3.50(1.00SD)age5-10
Ad: 2.50 (.67 SD); 3.50 (1.00 SD)</td></tr>
<tr><td>DS12K</td><td>.028</td><td>1.4</td><td>1</td><td>7.67</td><td>81.5</td><td>64.5</td><td>.0146</td><td>.0932</td></tr>
</table>

Population and Habit Dynamics Working Group

Member: P.Lahan, D.K.Ghosh, K.S.Varmain, B.S.Bonal, S.S.Bist

Introduction:

Previous distribution of the great Indian one horned rhinoceros (Rhinoceros unicornis) used to extend over a continuous belt along the lower foothills of the Indian and Nepal Himalayas. Various factors culminating in disintegration of this continuous habitat have finally resulted in the rhino habitat being confined to a few pockets. Most of these pockets are small and isolated, providing little scope for animal migration.

Of these, the primary pockets of rhino habit in India are on the Brahmaputra basin having rainfall ranging between 1800 to 3000 mm per year with a more or less uniform confident moistening of 0.7 to 0.9 for 4 to 6 months and 0.4 to 0.6 for the balance period. The alluvial of different nature as follows:

1. Low alluvial savannah woodland,
2. Moist Sal savannah and
3. Eastern alluvial grasslands.

Within these broad vegetation types the rhinos are now confined in the following pockets which have been subjected to study and observation.

Assam

1. Kaziranga National Park,
2. Mannas Tiger Reserve,
3. Orang Wildlife Sanctuary,
4. Pabitora wildlife sanctuary.

West Bengal

1. Jaldapara Wildlife Sanctuary,
2. Gorumara Wildlife Sanctuary.

Habitat Assessment:

The Indian rhino of the Order Perisodactyla, with capacity of extensive lower tract fermentation and with its typical setting of teeth pattern, mouth anatomy and volume of intake, is categorized under “bulk and roughage feeder”. With additional rumen/Reticulum volume of 53 % and 22% than other ruminants, it requires a microbial synthesis of food intake foremost 20 hours and a ceacum digestion for around 3 hours. Reciprocal to this is a very fixed energy output enabling the animal to male limited movement in its foraging efforts and requiring a major time slot of assimilation of food. Based on this pattern the Indian rhino is basically a grazer, the short grasslands being its prominent food habitat. But due to adverse shrinkage in habitat due to either density independent factors it is forced to take a considerable amount of browse material in its foraging strategy. Keeping all this in mind an effort was made to quantify and assess the population parameters and grass, browse available for rhino population in existing rhino areas.

The data on population number, structure and density was obtained from forest department census reports. The habits type, food availability and other related data ere obtained from the reports available ob these areas. The populations parameter such as growth rate, death rate, male-female ratio, female calf ratio and other related information's were arrived at from the census reports, natural and poaching (death) records. A previous study on rhino in Jaldapara by Dr. D.K. Ghosh, was utilized to obtain a food and feeding behaviors of rhino.

Table 1-5 summarizes the result. The table summarizes the following parameters:

1. Correlations between area available and the density of rhino in different habitat type.
2. Potential carrying capacity of the areas, taking into consideration substantial development in the existing habitat in correlation of food and shelter patterns.
3. Habitat type and population number,
4. mortality and growth rate and
5. Adverse factors in rhino habitat.

Chart 1. Correlations between area available and the density of rhino in different habitat types.

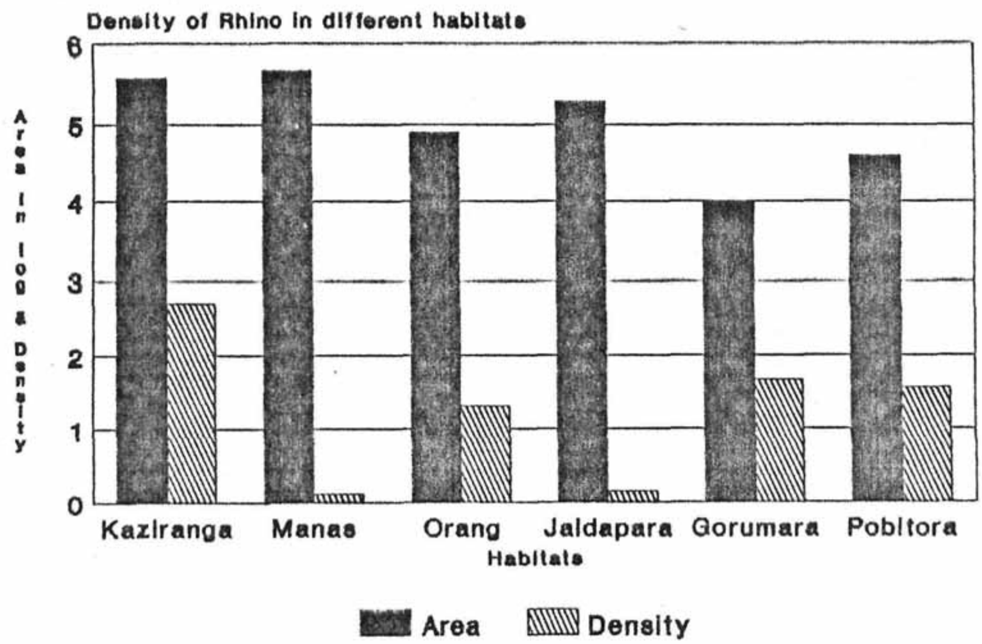


Chart 2. Potential carrying capacity of the areas, taking into consideration substantial development in the existing habitat in correlation to food and shelter patterns.

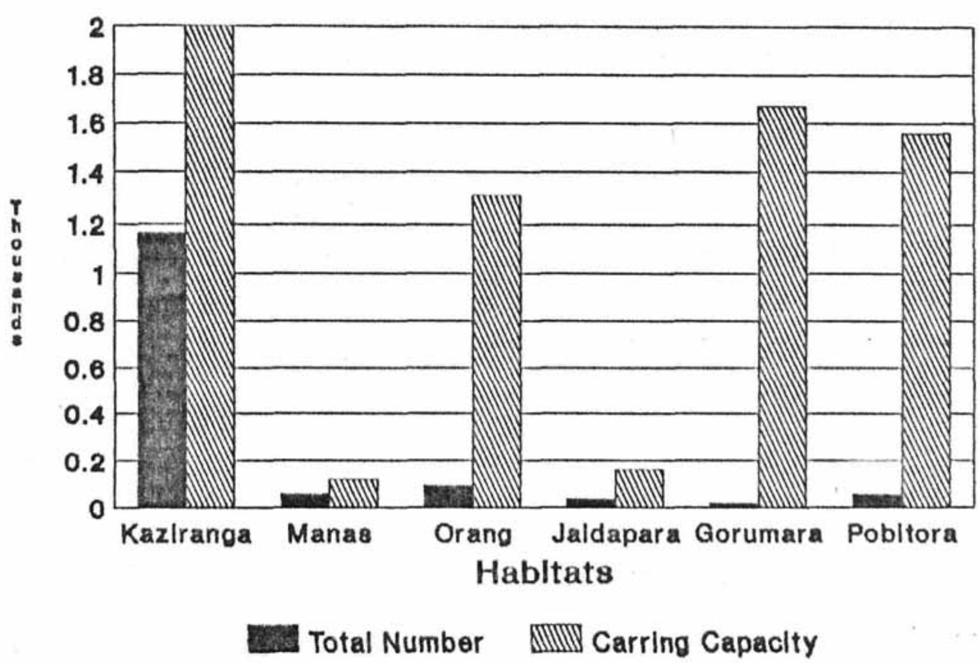


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Chart 3. Habitat type and population number.

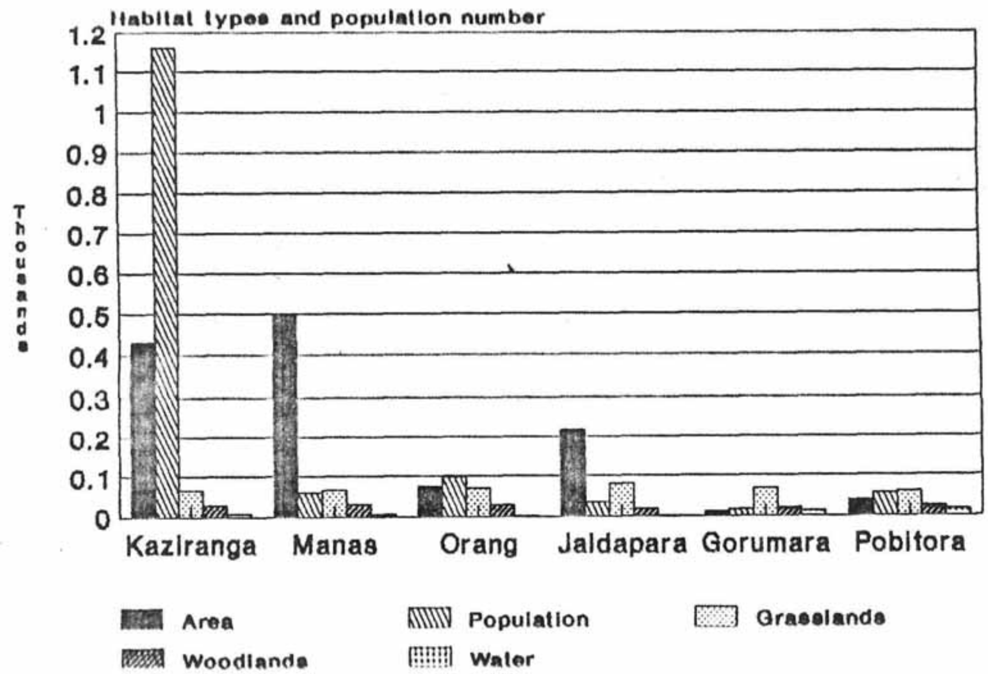


Chart 4. Mortality and growth rate

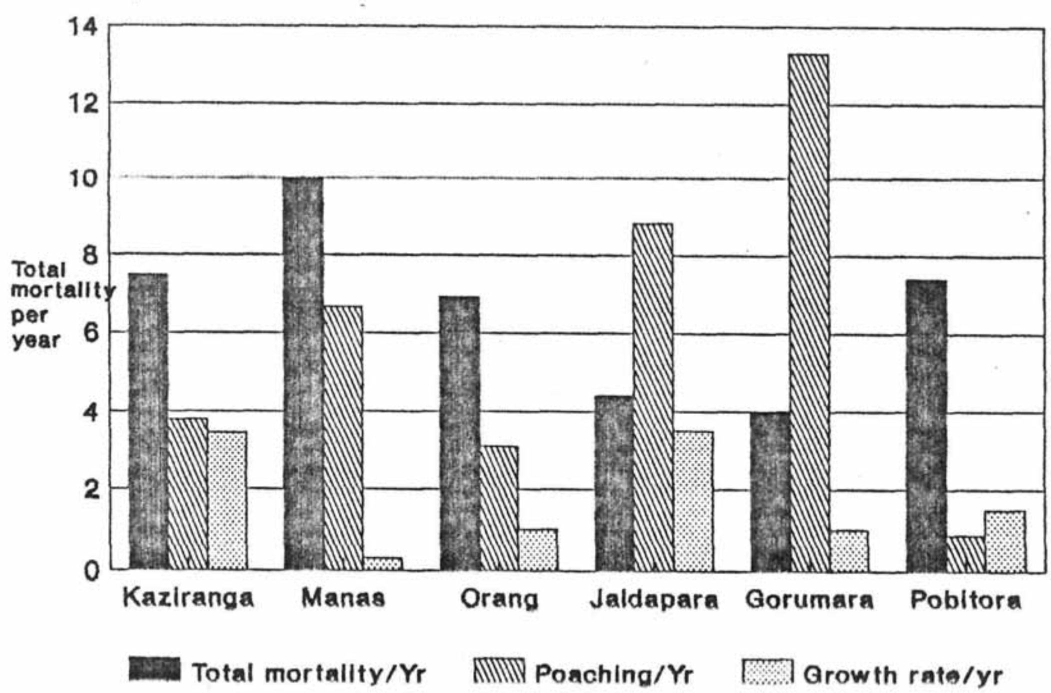


Chart 5. Adverse factors in rhino habitat

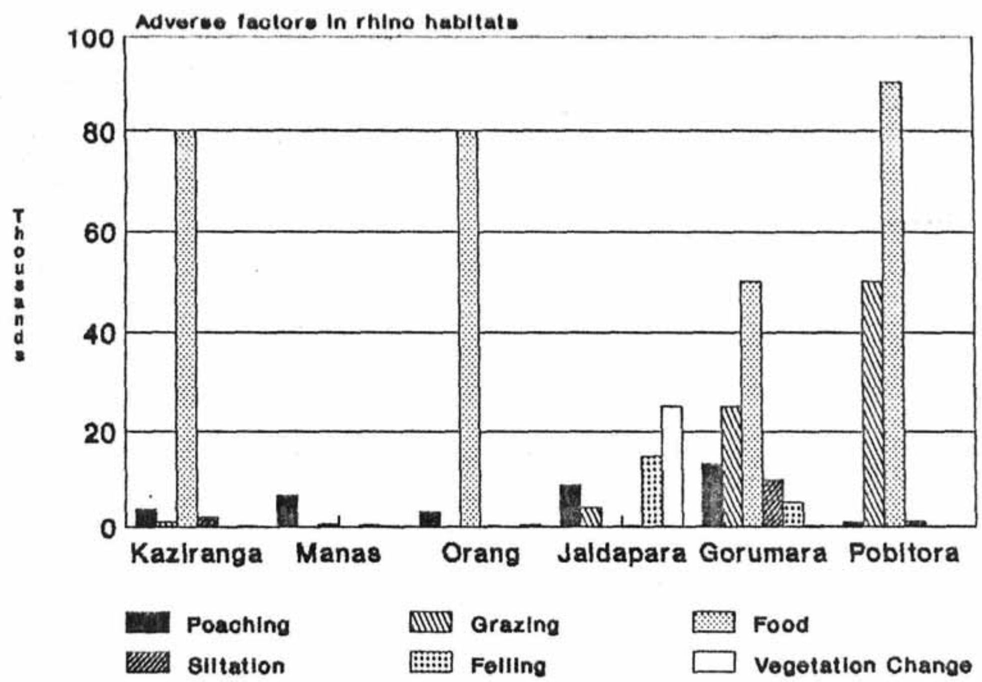


Table I : Rhino Population Density, Growth Rate Sex Ratio and Mortality

Name of reserve	Area sq. km.	Population size.	Density/ sq.km	Growth rate/year	Mortatily rate/yr	Poaching: rate/yr	Sex ratio F:M&F:C
Kaziranga	430	1164	271	3.45	7.47	3.8	1:1 &22:1
Manas	500	60	0.12	03	10	6.6	1:1 & 7:1
Oranga	74	97	131	1	6.91	3.09	1.4:1 & 5.1:1
Jaldapara	216	43	0.16	35	4.41	8.82	**13:1** &12:1
Gorumara	9	15	1.67	1	4	133	1.7:1 & 1.7:1
Pabitora	39	55	156	15	739	0.89	2.1:1 &42:1

Table 2: Habitat Assessment

Name of reserve	Area, sq.km.	Wood land %	Grass land%	Water bodies %	Encroach - ment %	Grazing %	Flooding %	Siltalion %	Felling %	Vegetation change %
Kaziranga	430	28	65	8	0	1	80	2	0	02
Manas	500	30	65	5	0	0	05	0	03	02
Oranga	74	2)	70	1	0	0	80	02	0	0
Pabitora	39	19	80	1	0	50	90	1	0	03
Jaldapara	216	20	68	12	0	4	. 0	0.1	15	25
Gorumara	9	25	60	15	0 ■	25	50	10	5	02

Name of reserve	Area sq.km.	Grazing sq.km.	Mdg.	Brows- ins	Water	Sis	Bor n	Tall	Other	Suffi- cient	In- suff.	Cover	Hiding
Kaziranga	400	45	30	0	5	0	0	10	10	Yes	no	25	15
Manas	500	50	25	0	1	1	0	20	3	Yes	no	30	20
Oranga	74	50	25	0	1	1	0	20	3	Yes	no	30	20
Pabitora	39	50	25	0	1	1	0	20	3	Yes	no	30	20
Jaldapara	216	40	10	2	0	2	2	15	29	Yes	no	35	25
Gorumara	9	35	14	2	0	2	0	20	26	Yes	no	45	30

Protected Area Management Working Group

Member : M.K. Nandi, S.K. Sen, V,K. Yadav, P, Vyas, H. Sajudin , Nina Sengupta, Pho;ip Wells

Management Objectives

The objectives of a strategy of protected area management are 1) the preservation pf existing biodiversity and 2) interspersion of habitat. Emphasis is on maintenance and attainment of ecologically viable population of Indian rhino in their respective ranges, and security for sympatric herbivores.

Management Strategies for Rhino Populations in Kaziranga, Manas, Orang,

1. Provision of genetic continuity amount rhino beating areas like Kazioranga, Orang and Laokhowa through expansion of existing protected area and building of corridors to facilities natural migration of individuals from one protected area to the other.
2. Rationalizing and reinforcing existing organizational structure(s) for an orchestrated and co-ordinates anti-poaching drive.
3. Intensification of anti-poaching drive:
   a) Strengthening of radio-transmission network through establishment of adequate fixed an mobile stations in all protected areas.
   b) Provisions of adequate mobile squads for land and waterways.
   c) Building up adequate numbers of trained elephants and surveillance towers, both to be manned by properly equipped armed personnel at valuable points for prevention of entry of organized poachers in the park. Elephants may be more useful than stationary towers because they can be moved at random ant at will and are, as such, unpredictable to poachers.
   d) Strengthening of an intelligence network for collection and transmission of information and introduction of a formal mechanism for rewarding informers and staff for good work in prevention and detection of poaching.
   e) Provision of social facilities to park personnel:
   (i) Through building up of infrastructure of accommodation, education, recreation and family welfare.
   (ii) Providing adequate financial compensation to staff in the form of ration allowance, field allowance and proper uniform.
   (f) Creation of a special legal cell for prosecution of offenders apprehended in connection with poaching of Indian rhinos and depredation of its habitat. (Some participants felt that the cases of poaching were not sufficient to justify a special cell for rhino alone).
4. To build up escape routes for a substantial part of population to meet the contingencies of high flood.
   a) Raising and widening of the existing central (east-west) roads to facilities intra-part traffic.

b) Raising some more artificial high-grounds for providing shelter to flood affected rhinos and other animals. Participants cautioned, however, against digging pits to get earth of high grounds and leaving dangerous traps for rhinos.

5. Habitat-management

a) Extension of the existing Kaziranga National Park by inclusion of 490 sq. km. In the north and south.
b) Identification of areas for building up corridors if necessary through resettlement of small enclaves for human habitations.
c) Eradication of weeds from grasslands and arresting colonization by woodland.
d) Maintenance of adequate water bodies to cater to the needs of foraging during pinch periods through desiltation of beels and eradication of undesirable aquatic vegetation.

Management Strategies for Rhino Populations in Jaldapara and Pabitora

1. Rationalizing and reinforcing the existing organizational structure for orchestrated and coordinated management and anti poaching drive(Jaldapara and Pabitora)
2. Intensification of anti-poaching drive, as in case of Assam population.
3. Habitat management

a) Identification and inclusion of additional rhino habitat to make room for growing numbers.
b) Eradication of weeds from grasslands and arresting colonization by woodland.
c) Judicious use of fire in a prescribed burning regime in restricted areas for production of nutritious fodder.
d) Amelioration of degraded habitat by raising fodder plantations.
e) Elimination of grazing by domestic cattle from prime rhino habitat in a phased manner for improvement of the habit and prevention of outbreak of cattle-borne disease(Pabitora and Jaldapara)
f) Diversion of controlled discharge of water from the existing channel of the Sil Torsa into its old course, the Char Torsa for rejuvenation of grasslands in Jaldapara block.

4. Translocation of compatible breeding stock from on e area to another to increase the genetic variability and to raise the recovery rate of the population. This should not be attempted unless 3d, (amelioration of degraded habitat) and 3e. (Elimination of grazing by domestic cattle) have been accomplished.

Management Strategies for Gorumara.

1. Extension of the existing protected area to include a variety of ecotypes suitable for holding Indian rhino and other ungulates
2. Intensification of anti-poaching measures, as has been recommended for the other populations.
3. Habitat management:
    a) Development of meadow in east-west Khunia forest village through cultivation of fodder grass and waterholes.
    b) Canopy manipulation in man made plantations and grasslands colonized by woodland.
    c) Judicious use of fire in a prescribed burning regime in restricted areas for production of nutritive fodder.

4. Research objectives should concentrate on the maintenance of this very small population as a gene pool to facilitate research. The strategy should be the study of reproductive biology of this small rhino population through registration of individuals and monitoring the population with reference to reproduction and population dynamics.

Reintroduced Population and Potential Areas for Reintroduction

The objective is to reintroduce Indian rhino in the potential areas of Assam state viz: Laokhowa WLS.: Burachapori R.F.; Kochmara R.F.; Kuruwa R.F.; Disangmukh area and some areas of Uttar Pradesh and West Bengal in its erst-while ranges.

a) Evaluation of habitat suitability index for reintroduction
b) Capture and translocation of breeding stocks from Kaziranga N.P.
c) Monitoring and assessment of reintroduction population and its habitat.

Management Strategy for Dudhwa

1. The objective of management is the attainment of an ecologically viable population within a reasonable time-span

a) To strengthen the existing breeding stock by inducting additional breeding stock (2 males+4females).
b) Expansion of the power fenced area in phase manner to about 40 sq.km. To ensure survival of growing population.
c) Removal of the power fence on attainment of founder population of 50 individuals.

Common Objectives and Strategies for Rhino bearing areas

1) Objective for rhino bearing areas is economic rehabilitation of fringe population through provision of adequate inputs on beneficiary oriented and community development items identified in consultation with local people.
a) Face to face communication with target groups and local leadership
b) Formation of ecodevelopment committees involving existing rural institutions including Panchayats.
c) Preparation of micro-plans for formulation of site specific eco development plans
d) Organization of awareness campaigns and integrating the message of conservation through the local cultural ethos.
e) Creation of international awareness to bring in pressure on rhino horn consuming countries to stop illegal trade in rhino horn and other body parts.

2. Wildlife-tourism

The objective of wildlife tourism is the judicious promotion and regulation of tourism in protected areas

a) Development of appropriate site specifies interpretation facilities.
b) Lifting of existing restrictions for visit by foreigners in rhino beating areas to raise additional resources.
c) Evolving a mechanism for ploghing back tourism revenue into conservatism areas and sharing of such revenue with people in the fringe area.

3. Training

The objective of training is to impact knowledge to park personnel on issues relevant to management so as to achieve management goals. Training topics should be:

a) Grassland ecology and managing such grasslands for the rhino populations.
b) Tranquilization, rescue and veterinary care.
c) Management of the captive elephants.
d) Census techniques of rhinos and its associated species.
e) Erection and maintenance of energized fences
f) Interpretation and extension.
g) Arms training to park personnel

4. Monitoring:

5. The objective is to monitor the habitat and population in rhino bearing areas on a two year basis.

a) Using satellite imageries of rhino bearing areas for assessment of extent of habitat suitable for Indian rhino.
b) Undertaking census of rhino population at regular intervals to classify them into age and sex classes.

5. **Veterinary care**

The objective is to ensure a healthy wild population of rhino and other associated species.

a) Establishment of suitable veterinary units in all protected areas.

b) Immunization of domestic cattle in fringe area to prevent out break of communicable diseases like anthrax, foot and mouth, rinderpest, etc.

c) Monitoring the health of wild population.

6. **Research**

The objective is to improve management through continuous theoretical and applied research of any type that would shed light on the behavior and biology of the species and assist in assuring its ling term survival.

Threats Working Group

Members: Vivek Menon(Facilitator),J.T.Mathew, Mohit Aggarwal, Suprava Patnaik Esmond B.Martin, E.A.Sumardja, S.K. Das, B.R.Sharma,John Williams.

Introduction
The group decided to focus primarily upon a ten years horizon, thorough for selected areas of discussion, a longer term view was discusses. The discussion was broken into three broad areas, dealing with the relationship of the rhinoceros to people living beyond the boundaries to the park. These were:

Trade Issues: focusing on the rhino horn. Discussions included legal structure at the international and national levels, enforcement, poaching techniques, poaching pressures, market trends, trade routes, and substitutes for rhino horn usage.

Human Impacts: (other than poaching), focusing to considerable extent on the communities in proximity to the protected areas for the rhino. The di8scussions encompassed demographic changes, pattern of dependency, attitudinal changes, socio-economics, and political/civil unrest.

Public Awareness: Including people's participation and NGO involvement; motivation of service personnel, education, extension and interpretation programmers; and eco-tourism.

Trade Working Group

Members: Vivek Menon (Facilitator), J.T.Mathew, Mohit Aggarwal, Suprava Patnaik, Esmond B.Martin, E.S.Sumardja, S.K.Das, B.R.Sharma, john Williams.

Trade

Legislation-International, National

International
What is the impact of the international legal structure on pricing?
A major assumption is that the legal international trade in rhino horn will not reopen, and that this is positive with regard to the Indian Rhino. If the African Rhino horn trade reopens, this would reopen the market that would have a negative effect on the Asian populations. The probability of the existent CITIES ban being lifted is estimated to be less than 5 percent, because 80 countries (two-thirds of the Conference of Parties) would have to approach it.

Based on increasing stockpiles, there will be continuing pressure form "Southern African countries to reopen the trade, but the chances are still slim that the trade will reopen.
Note: the destruction of existing known stockpiles of rhino horn would very much decrease the possibility of reopening the trade, as suggested by Resolution 6.10(CITIES) which is technically voluntary.

National
Area effective national legislations in place in range and consumer counties?

Range Countries
Both Indian and Nepal have legislation protecting e rhinos, in effect for many years.

Consumer countries
The penalties in the consumer countries (China, Yemen, and Taiwan) are so low for dealing in rhino horn, and so little enforced that effort should be made to increase the penalties in those counties. This would deter smuggling efforts. (Note that the response of Taiwan and China to the US Pelly Amendment has been to ban the internal trade in rhino horn)

In Taiwan, there are 3-5 tons of horn stockpiled [300 kg are used annually]. China had 81/2 tons stockpiled,] 650 kg used per year]. With rhino horn prices decreasing, and in our opinion continuing to decrease, stockpiles now have a risky investment.

During the next decade, existing stockpiles can mote than meet the projected demand, and it is unlikely that the price will go up. The long term outlook beyond a decade depends primarily upon the continued use of rhino products of medicines. If such use is discontinued, a continued decline in price would be expected.

Note: there is domestic trade within Nepal for Rhino products other than horn, such as urine, bold, and nails, but existing legislation should discourages poaching just for these products.

Enforcement

What is that state of Enforcement in Indian and Nepal?

Potential poachers perceive the enforcement in Nepal to be strong. However, the perception may be stronger than the fact. In India there are 10 or 12 departments concerned with enforcement concerning rhino poaching and related trade. Coordination between these departments needs to be strengthened.
Intelligence and Informers

In parts of Africa (particularly Namibia), there are large payments to informers which results in significant successes in catching poachers/traders. In India and Nepal, intelligence is a low priority. There needs to be established well-publicized reward schemes within intelligence networks which will provide significant payments for good information.

Intelligence is the aspect of enforcement that would bring the greatest success for the least investment. The present strategy on poaching needs to be closely examined. While more money is required for patrolling, firearms, etc., a higher priority is required for intelligence network. One study in Zambia showed that investment in information gathering from informers is 30 times more effective than other strategies.
Other agencies than wildlife needs to be involved after the rhino is poached. The gold and narcotics section of the police agencies in Namibia are the enforcers. Other agencies (i.e., police, revenue intelligence) with existing enforcement capability, should develop information unit's specific to rhino horn.
In Assam, it would be most desirable to have an elite group of forest people trained in combating poaching. Intelligence support from outside would be most welcome.

Poaching techniques

In Nepal, poisoning as poaching techniques has recently been introduced.
In India, pit poaching and shooting were the traditional techniques. But more recently, electrocution and poisoning have been added to the poachers' arsenal. The traditional pit trapping has declined greatly. More traditional techniques have been used in West Bengal, while new techniques are coring into Assam.

In general, more powerful weapons and techniques are available which makes it easier to kill the rhinos. Since more effective tools are available for poaching, this leads to a potential increase over time in the kill, in the absences of changes in other factors

Poaching pressure

The following section describes for each protected area the present population, recent poaching activity, and projected rate of poaching over the decade

Nepal

Area Royal chitwan
Population: 375-400rhinos
Recent poaching: none for many years, but has restarted again. Now it is having
Minor fluctuation but an upward trend per year. 1% per year in
Recent past
Projected pressure 1-3 %per year projected for next decade

Area Royal bardia
Population: 43 rhinos
Recent poaching: Almost similar enforcement measures as in Chitwan, but
Because of proximity to the Indian border, there are increased
Probabilities of poaching. Three rhinos were poached from
Bardia in 1993(7.5%)
Recent poaching: 5% per year

INDIA

It was noted that a number of animals, as many as 25,exist in pockets outside of reserves in Assam and West Bengal, and are vulnerable, poaching pressure on this population is unpredictable.

Assam

Area. Manas
Population: 60 rhinos
Recent poaching lost 22 rhino in one year (1993), built average of 5-6 % per year in recent years
Projected poaching 5-6%
The chance of a 20 percent kill is none in any given year

Area Kaziranga
Population: 1164 rhinos
Recent poaching now losing 30-40 per year, now 3-4 percent per year
Projected poaching: projection is 4 percent annually \
Because this area now has the largest number of animals Poached, it is a high priority area for action

Area Orang
Population: 97 rhinos
Recent poaching: 1 poached in three years
Projected poaching: 1-3% annually

Area Pabitora
Population: 56 rhinos
Recent poaching: 3 out of 56 poached last year.
Projected poaching: 6% poaching annually projected for next decade

Over the decade this could (20 percent chance) increase to 10 Percent.

West Bengal

Area Jaldapara
Population: 34
Recent poaching 3%
Projected poaching 2-3 percent

Area Gorumara
Population: 13 rhinos
Reaching poaching: 1-2%
Projected poaching: 1-2%

U.P.

Area Dudhwa
Population: 11
Recent poaching: not a single case so for, rhino are now kept behind

an electric Fence. When th e population exceeds approximately 25,a Release outside the fence is planned,
Projected poaching: 5-1%

Trade routes

The information on trade routes for rhino products out of India and Nepal is sparse, but a few to an estimated routes have been documented: (1) from Assam West Bengal through Bhutan to SE and East Asia; (2) from Assam and West Bengal Through Nepal into SE and East Asia; (3) from Assam to Myanmar and on to SE Asia; and (4) from Assam and West Bengal to Calcutta (ap-parently now little used).
Porous borders such as the ones shared by India with Bhutan, Nepal, and Myanmar, encourage poaching. Such borders only more clearly indicate the need for intelligence networks.

Substitutes

1. Discouraging the use of Rhino horn in medicines. The government in Japan discouraged the use of horn for medicinal purpose, and there is no evidence of illegal movement into Japan since 1980. If these of horn in medications are sufficiently discouraged, it would lowest demand and presumably, the price.
2. Dagger horn in Yemen. The substitution of buffalo horn and other substitutes for rhino horn needs to be further encourages.

CITES Membership for border and high use countries

Bhutan ,Taiwan, etc.should be encouraged to join CITES.

Specialized policing genies

Investigation of Rhino poaching/smuggling case should be entrusted to the specialized agencies working on a national level (e.g. recent past g., C.B.I., and I.B. in India) so that the whole gang of rhino poachers/smugglers (who are seldom confirmed to a single state) can be exposed and prosecuted. These agencies even have access to INTERPOL to follow up a case across the national boundaries.

Human Impact Working Group

Members: Vivek Menon (Facilitator), J.T.Mathew, Mohit Aggarwal, Suprava Patnaik, Esmond B.Martin, E.S.Sumardja, S.K.Das, B.R.Sharma, john Williams.

Population

Information was obtained on population for a number of villages adjoining the jaldapara reserve. No data was available at the workshop for Assam or Nepal although there are studies on this subject for Kaziranga, Bardia and Chitwan. Such studies would be useful in planning eco-development for communities in all locations near the protected areas for the rhino. The data for a cluster of three villages adjacent to Jaldapara are shown in figure 1. The following points were made:

1. Fertility has show modest declines over the period, from a Total fertility Rate of 4.8 in 1971 to an estimated 3.7 percent in 1991. There was some variation in the fertility rate in the villages. Family planning practices are almost nil, Family planning support is available, but there is no extension work, materials are expensive for the villagers, and health facilities for these villages are limited. Village women mostly go to the hospital for delivery. Changes in fertility do not greatly affect the short term growth of population, due to population momentum. However, the maintenance of high fertility over the next three decades would result ion continued population growth in the following 25 years.
2. Mortality showed improvement from 1971 until 1990. However, there has been an alarming increase in mortality including child mortality since 1990, due to an increase in cerebral malaria. Malaria generally is not treated in the villages.
3. There has been substantial in –migration from Bangladesh over the period. This was heaviest in the 1970's and during the most recent five years. There is a possibility that there will be net out-migration from the villages or urban centers starting in the near future. Over the next three decades, the out-migration of small numbers of people from these villages has a highly significant impact on reducing population growth. In short term, migration has more impact on size of population than changes in fertility.
4. From 1971 to 1991, the number of people and the house holds has approximately doubled in number. A substantial part of this increase is attributed to in-migration of ours holds from Bangladesh
5. The number if households, that will be in these villages after 20 years (2011) is not much affected by fertility patterns of population programs. Hence, baring major catastrophe or social dislocation, the number of households that will be here us 2011 may be estimated with reasonable accuracy. These household increases in number are seen in figure 1.
6. The population change has dramatic impacts on land use patters of the local population. In 1971. The village was relatively egalitarian, and most of the households have between 2.5 and 6.5 acres. Very few were landless. But by 1991, 35 percent of the households had less than 0.5 acres, and a

considerable majority of the households has less than 2.5 acres and could not produce the majority of the food they consumed.

7. The entire increase in the number of households over the next 20 years will consist of households that are extremely land poor, or almost landless. These households have far more dependency on the reserve, not only for firewood, wood, food, and grass for their own consumption, but as a source of resources for sale. Data have been collected on the present patterns of collections by the land poor households.
8. The level of fertility will have a relatively great effect on the size of the population 30 or 40 years in the future visited, a near stationary population could be achieved by the year 2015 with a population around Jaldapara as an example that would be not more than double the present population. This would require major investments in a healthy infrastructure providing materials child health care and family planning services, plus participatory population outreach, which could be part of other participatory with the Villages.

Patterns of Dependency:

All households in villages are dependent upon forest for fuel wood. Land poor households have additional depended on the forest. 75 percent of the landless people get 30-50 percent of their income from the forest (fuel wood collection for sale, and collection of non-timber products, such as grass, food, etc.)

Households with cattle depend on areas of the reserve for the grazing of their cattle. This grazing poses dangers for rhino and degradation of some grassland.

In the short term, human dependency on wooded areas does not directly affect the rhino habitat, but it could affect it indirectly though overall changes to the ecosystem.

Changes in Attitudes

1. **Attitudes to the Rhino**

1a. Jaldapara

Field work ion villages around this particular reserve only, indicated generally positive attitudes toward the rhino art the present time, unlike most of the other areas. If rhino were more numerous (100 animals is the projected carrying capacity, three times the current number), the rhinos would go out of the serves frequently and negative feelings could increase.

1b. Kaziranga

There are extensive crop damages by the rhinos. If local support the poachers, it is due to the socioeconomic conditions of a small percent of the population. Local people need compensation for the damage occasioned by living adjacent to these animals. They need massive ecodevelopment programmers in the villages surrounding Kaziranga.

1c. Nepal
There is considerable animosity by the local people to the rhinos, because of the number of animals that come out of the park into the fields.

2. **Attitude toward the reserve**

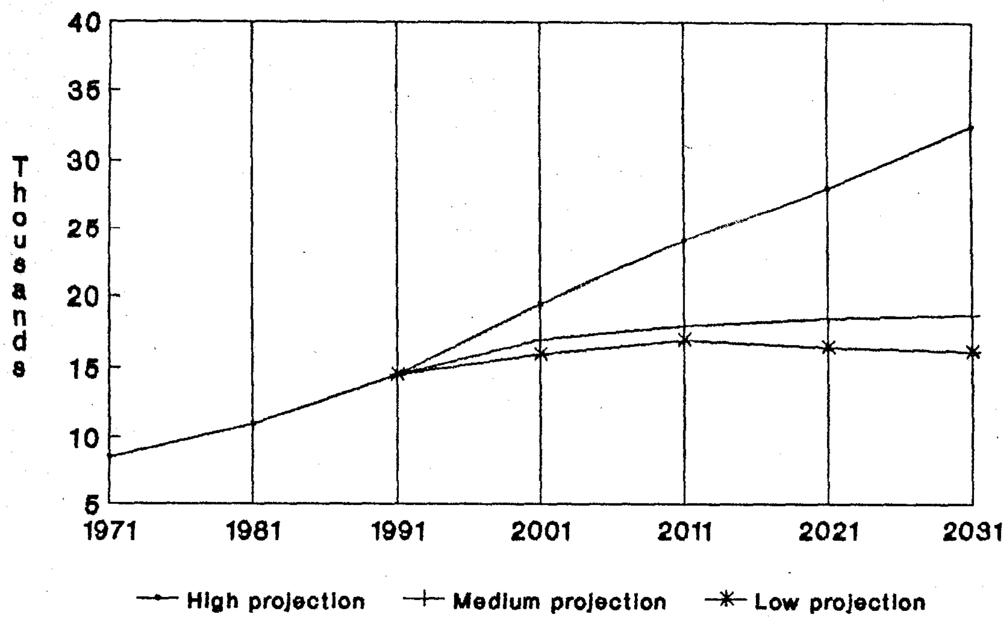
Asking the local people to stop the use of the reserve meets with local opposition. There is some grazing and cutting of grass allowed in some areas. Imposing too much protection without giving an alternate strategy does create ill-will toward the reserve.

The antagonism will be greater where there are extensive property damages or threat to personal injury. These damages and dangers of not come primarily from the rhino, but from other wile mammals, such as wild boar, elephant, and leopard. These damages coming from the reserve require compensation.

2a. Chitwan
The local people like to put their cattle into the park, and they are chased out,; cattle are sometimes confiscated, creating lot of ill feeling.

2b. Kaziranga
There are 130 villages (20,000 populations) on the southern bundry. There are also villages across the river on the north. The park creates some economic opportunities for these villages. Park personnel hire villages (only) for work; grass road construction, and other jobs. The park has constructed high school and other facilities for the local people.

Political and civil Unrest:
Civil disturbance has affected rhinos in Kaziranga (in particular), Manas and Laokhowa, Militants have killed some rhinos; even it the militants do not directly hurt the rhinos, opportunities may take advantages of the breakdown of law and order. In west Bengal, no problems have been seen.



Note: Villages are Jaldapara (includes Pradhanpara & Natunpara), Lakshmandabri, and Sidhabari

Public Awareness

Members: Vivek Menon (Facilitator), J.T.Mathew, Mohit Aggarwal, Suprava Patnaik, Esmond B.Martin, E.S.Sumardja, S.K.Das, B.R.Sharma, john Williams.

People's Participation and NGO involvement:

People's participations in the management and use of protected areas is dependent on the legislative structure which allows or prohibits such use. In Nepal, the legislation allows for some collection. The legislation in India currently prohibits the use of forest products by the local communities in the reserves. The development of participatory approaches is essential in areas where use of protected are resources must be made compatible with conservation objectives.

With regard to the rhino areas, only in West Bengal have first steps been taken toward the establishment of participatory mechanism. In Jaldapara, the West Bengal Forest Department has established eco-development committees with both reserve official and elected community members. The committees have served to greatly improve the quality of the dialogue between the reserve staff and local people. The committee structure is further used for channeling eco-development funds. The response by the community members has been very positive. West Bengal has been playing an important role in developing this sort of participatory models bringing the cooperation of local villagers in conservation management. In Assam, a structured eco-development programme is on the drawing board but has not been funded. The parks and reserves hire local people for daily wage labor ad recruit staff from the villages. A few other benefits have been provided to local communities.

In Nepal (Chitwan and Bardia) local villagers are allowed in the parks for 15 days per year by permit. The cost of the permit is extremely low, and the villages may take out as much thatch as they can non-mechanical, means.

Motivation of Service Personnel:

Training
To ensure optimum protection of protected areas, the needs of the forest personnel must be satisfied. In addition, specialized training is required in (1) wildlife; (2) interacting with local communities; (3) training.

Most of the forest guards are trained for commercial forestry, but not for wildlife. There is some training for divisional forest officers and range officers, but no training of forest guards exists in West Bengal or Assam.

There is great need for training the protected area personnel in community relations. Building rapport with the local communities is essential in graining and maintaining their cooperation, and minimizing negative impacts (poaching, habitat degradation, etc).

Incentives
Motivation is also associated with incentives. There is a need for hazard allowance for forest guards, who are often in the forest comps while their facilities are living in distant villages. There is an official policy in India for giving rewards for outstanding work or special accomplishments, but the rewards are small, when given.

Education, extension, and interpretation programmes
In India, most people surrounding the rhino reserves have never been to school, and illiteracy among adults is high. (In the rural parts of Jalpaiguri district, 70 percent of the population is illiterate).Improved education of the local people is essential for the long term health of the conservation areas. The forest department needs to become a special advocate to improve the education in the communities that border the reserve. Such education is a prerequisite to many eco-development projects, and is viewed as a pre-requisite to reducing population growth. Interpretation facilities made available to the people surrounding the reserve should be greatly expanded and improved.

Eco-Tourism
Wildlife tourism exists for most rhino preserves India and Nepal, with the present exception of Manas. Economic benefits of tourism should be channeled to local communities whenever possible, and can serve to increase local incomes. Eco-tourism involves (1) experiences of wildlife; (2) minimal impacts on species and habitat; (3) minimal negative impacts on local communities.

Bhutan and Taiwan should be encouraged to join CITES.

Investigation of rhino poaching/smuggling cases should be entrusted to the specialised agencies, working on a national level (e.g., C.B.I and I.B. in India) so that the whole group of rhino poachers/smugglers (who are seldom confined to a single state) ca exposed and prosecuted. These agencies even have access to INTERPOL to follow up a case across the national boundaries.

Captive Breeding and Disease Management Working Group

Member: S.C.Sharma (facilitator), S.Battacharya, N.C.Bahuhguna, M.Dee, V. Kumar
Pillai, T.Chakraborty, M.Adi, A. Bonal

Captive Breeding Plan for Indian rhino in India

The working Group discussed the history and current status of Indian rhinoceros in Indian zoos at length and submitted the following information and recommendations for Indian zoos presently holding the species.

1. The Zoos that have successfully bred Indian Rhinos in India are Mysore, Guwahati, Calcutta, Delhi, Hyderabad, Patna, Chandigarh and Kanpur. Of these, Delhi, Calcutta, Guwahati and Patna have breeding pairs,

In addition to the above zoos, Nandankanan Biological Park, Orissa also has a pair, but to date no breeding has been achieved since their arrival in 1974 and 1976. At the present time, it is unknown as to why these animals have no bred.

Recommendation: The zoos that have had breeding successes should be given priority when pairing animals.

The current situation at Nandakanan should be investigated as to why no breeding has occurred. Estrus cycle in the female should be determined. If she proves to be sound, she should have access to the make that she is paired with. If no breeding occurs, then another male of breeding age should be made available to her, either by transfer of the male from Chandigarh or transfer of the female to Chandigarh if facilities are available.

2. The following zoos having single animals and also have experience in breeding rhinos:

Zoo	Sex of animal	Age of animals
a) Kanpur Zoo	Female	20 years
b) Hyderabad Zoo	Male	12 years
c) Chandigarh Zoo	Male	17 years
d) Mysore Zoo	Male	18 years

Recommendation: All efforts must be taken to ensure maximum breeding potential. A breeding age female must be made available to the proven breeder in Chandigarh. Breeding age females should also be made available to Mysore and Hyderabad, as they have previous breeding experience with this species. A breeding age male should be place at Kanpur with the proven breeding female. Moreover, Kanpur Zoo has four male rhinos born from this adult female. One of the Zoo-bred male rhinos of Kanpur should be exchanged with the breeding age male at Bombay so as to add more genetic diversity.

3. The Bombay Zoo and Trivandrum Zoo have males, but have had no breeding experience.

Recommendation: In the future, as more zoo bred females become available, these two zoos should receive priority.

4). Guwahati Zoo at present is being used as an orphanage for rhino and a breeding centre. At present it has a surplus of males.

Recommendation: Guwahati zoo should not be used as an orphanage as this arrangement has affected the management of the rhino that are currently there. The orphanage should be attached with the Kaziranga National Park or other rhino rearing area where facilities could be established to rear young animals. After rearing, these young and sub-adult animals should be re-introduced into the National Park. If more females could be available from the orphanage, these animals may be put in the exist breeding programme. Surplus males could be used for re-introduction research.

5). In some zoos like Calcutta, no breeding has occurred since 1984 through the present pair has bred once before. It is now reported that this pair has been showing signs of reproductive behaviors but little information is available on the efforts made so far in detecting the etiology of this fact.

Recommendations: After discussion with the participant representing Calcutta Zoo, it is proposed that the moat should be modified to slope gradually on the animals' side. This will allow more room for the animals to move. More visual barriers should also be provided to give a better opportunity for courtship behaviors and to avoid injuries during such behaviors.

The following information will be helpful when attempting to breed this species:

a. Signs of heat-Restlessness, frequent urine acquiring, and lack of appetite, whistling, valve flashing, and the vulva becomes swollen and pinkish in color. The female and the male will seek each other's company.

b. The estrus cycle should be observed closely; In general the estrus cycle is approximately 30-45 days. From our present knowledge of the Indian rhinoceroses in regard to reproductive biology, it appears that males in captivity can breed up to 39 years while in the case of females it is up to 31 years. An observation has been made that if the male whistles during courtship behaviors the chances of breeding are higher.

c. The female remains in heart for 18-20 hours. So the male should be allowed close proximity to the female for the few after the onset of heat and should be allowed to enter in the enclosure of the female between five-six hours when the peak period is approaching.

d. As far as breeding behavior is concerned, all zoo animals care staff should observe points a, b and c mentioned above so as to maximize breeding potential.

e. Animal care staff – all personnel working with rhino should be give proper training on reproductive biology and physiology of the species (see a, b, & c).

General Recommendations:

1). Though at this stage, we are not in a position to reintroduce adaptive born rhino into the wild, in the future if the breeding programme goes well, we should think over the probabilities of reintroducing those captive born individuals. The group recommends a feasibility study to determine if indeed reintroduction of captive borne rhinos into the wild is a possibility, and is so what captive management activities should be undertaken to ensure a successful project. Consultation with the Reintroduction specialist Group of the IUCN is highly recommended.

2). All date related with each individual, namely date of birth, data of any acquisition , transfer, data of death cause of death should be made available to the National Studbook Keeper (Kanpur Zoo), the Species Coordinator(AddI.I.G.,Wildlife), and Central Zoo Authority.

The National Studbook Keeper should take all the responsibility to send all sinformation to the International Studbook Keeper.

3). All the zoos that maintain the species should have educational materials available to the visitors and they can be in the form of signage, brochures, or pamphlets in the; light of conserving the species.

HEALTH AND DISEASES

1). With respect to health and disease, there is little information available about neo-natal mortality, infectious disease survey and post mortem result of rhinos in captivity. There are also no authentic records available on the trilogy of mortalities in the wild which could be helpful to combat health hazards in captivity.

Recommendation: Every zoo that maintains this species will perform post-mortern for each and every animal and the results should be made available to the Regional Studbook Keeper, Species Coordinator and Central Zoo Authority. The post=mortern results may be maintained in accordance with the format as already laid down in the guidelines by the Central Zoo Authority. Additional required information may be added to the existing format of C.Z.A.

2). Infectious diseases have been found to cause a good percentage of mortality. Some viral infections were reported from Hyderabad Zoo and bacterial infections from Guwahati Zoo. The causative agents appear to be viral and bacteriological.

Recommendation: The disease which can be prevented by periodical testing and vaccination like rinderpest, hemorrhagic septicemia, and tuberculosis should be taken into consideration for routine prophylactic measures. The treatment records should be kept properly.

3). Fecal sample examinations hold be done on a regular basis for the detection of parasites and the treatment should be followed accordingly. A heavy parasitic load may be an important factor in infertility.

4). Although the group, members were not involved with the wild populations they recommended that post-mortem examinations should be done by a group of veterinarians so as to have an idea about the diseases pattern in the wile. This will be useful in planning future interactive management strategy. The results from the wildlife department be made available to the studbook keepers, species coordinator and C.Z.A.

5). Artificial insemination. At this point, the technology is not available for AI. We need more information's on the reproductive biology of this species. Perhaps this technology will be available in the next 3-5 years. At that time A1 could be revisited. The group did not recommend hormonal manipulation at this point.

Translocation and Reintroduction Working Group

Members: R.N.Hazarika(Facilitator),J.D.Sale, N.Van Strien, Mohd, Khan, S.Bajmiaya, D.N.S.Suman, A. Bhattacharya(Secretary)

Objectives of Translocation

1. To strengthen non-viable populations in areas which have adequate potential for becoming permanent self-perpetuating populations.

2. To establish new populations by reintroduction in suitable areas (habitat and security) where it was indigenous before its extermination within the species historic range, preference being given to area which have recently lost rhinos. Only where the original causes of extermination have been removed, or are in the process of being removed, and where habitat requirements of the species have been satisfied. Here namely Laokhowa W.L.S of Assam may be regarded as an example.

3. To maintain high heterozygosity in the population

4. To distribute populations over a large geographic range area in order to prevent loss of the species owing to mass catastrophy.

Identification of the recipient areas: Characteristics (Basic criteria).

1. The extent of recipient areas must have adequate rhino habitat for minimum of 100 individuals.

2. Legal status: Area should have the strictest possible legal protection status, e.g. national park and Wildlife sanctuaries which are the strongest in India

3. Actual law enforcement on the ground must also be of high quality, e.g. no significant poaching case in recent years.

4. Area should have a management plan and full implementation there of including adequate infrastructure with adequate elements of proper management of the translocated/reintroduced population.

5. All the above characteristics should be the subject of detailed of the proposed area.

The following expertise should be represented in the study.

a. Wildlife Ecologist
b. Vegetation/Ecologist/Botanist
c. Management / Law enforcement

d. Sociologist
e. Captive management specialist

Funding

A detailed budget must be prepared and funding should be assured before the commencement of the project

Preparatory Phase

1. **Composition and quality of introduced group**

It is recommended that in the case of a location which currently has no rhinos, an initial (in the first instance) reintroduction should be minimum of 10 animals consisting of 3 males and 7 females. It is important that animals selected should be young, healthy individuals. The optimum age group being young adults at the beginning of their reproductive life. Such animals are better able to withstand the stresses of translocation and are also ready to contribute reproduction in the new areas. Old adults should be rigorously avoided. After breeding of the initial group has been successfully established supplementation by further translocation programme should be undertaken.

2. **Identification of donor area.**

In the first instance suitable animals for translocation should be sought from pocketed or isolated groups (doomed animals) whose future existence is in danger. First priority will be given to pocketed animals in area which have no legal protection status. For example animals which have permanently strayed from protected areas. The next priority would be to examine the possibility of surplus animals being available in protected areas, bearing in mind that high density of rhinos does not in itself necessarily imply that carrying is exceeded.

Release Phase

Methodology of capturing and translocation:
Preferred method of capture should be drug/chemical immobilization and subsequent tranquilization (sedation) during transportation and transit. If feasible, it is recommended that captured animals be immediately dispatched to the recipient areas where they should be held for an in situ acclimatization period in stockade appropriate measure such as electric fencing must be implemented to present this. Depending on food availability released animals should be initially restricted to an area totaling 2 to 3 km per animal.

Follow up Phase

Monitoring of released animals:

It is extremely important that the released animals are systematically monitored including their effect on the habitat and till such times as they have established equilibrium with the new surroundings and are breeding successfully. It may be considered whether radio collaring of a small number of individuals should be undertaken as an aid to monitoring their movements.

In cases where new animals are being introduced into an existing population great care should be taken to avoid adverse interaction between existing animals and the newly introduced ones. Adult males should be especially monitors in this regard.

FUNDING

Members, S.S. Bist (Facilitator), V.P. Singh, S. Pal Choudhury, R.P. Saini, R.S. Prasad

After discussion with the Management Group, funding proposals have been assembled us per broad heading mentioned below, keeping in mind the management requirements of the rhino populations of different sizes in India. Proposed amounts have been figured in Millions of US dollars for submission to international aid agencies.

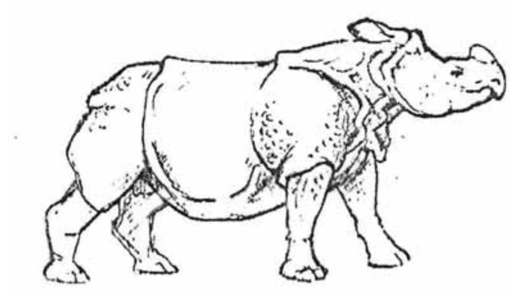
FUNDING/EQUIPMENT REQUIRED FOR THE NEXT 5 YEARS FOR MANAGEMENT OF RHINOS IN INDIA				
Items	W. Bengal	Assam	U.P.	Total
1. Re-Inforcement of the existing protective	0.17	16.70	0.015	16.885
infrastructural facilities & antipoaching measures.	0.14	0.20	0.0015	0.345
a) Communication network	0.03	0.035	0.005	0.070
b) Wireless network	0.07	0.0325	0.015	0.410
c) Arms & Ammunition	0.035	0.17	0.015	0.220
d) Water tower, Night vision devices/Binoculars etc.	0.05	0.085	0.005	0.14
e) Intelligence network	0.65	0,00	0,035	0.685
f) Mobile Squad (land & waterways)				
g) Construction of Boundary wall, energised fences, etc.				
2. Habitat Management	0.17	0.17	0.00	0.34
a) Removal of water hyacinth & desiltation/diversion	0.105	0.10	0.35	0.555
water channels	1.000	0.35	0.00	1.350
b) Habitat manipulation				
c) Relocation of enclave villages				
3. Veterinary Care & Rescue of marooned animals	0.065	0.165	0.015	0.245
a) Establishment of Veterinary Units	0.05	0.055	0.015	0.12
b) Cattle Immunisation programme	0.005	0.025	0.065	0.095
c) Rescue operation Centres	0.00	0.035	0.00	0.035
d) Captive breeding Centres				
4. Support for security to Staff	0.05	0.115	0.015	0.18
5. Eco-development	1.000	7.000	0.35	8.35
6. Compensation Payment	0.00	0.400	0.00	0.400
7. Translocation of Rhinos for re-introduction in viable populations	0.335	0.335	0.330	1.000
8. Wildlife tourism and Nature Awareness programme	0.150	0.680	0.085	0.95
9. Training of staff	0.025	0,035	0.015	0.075
10. Research, Monitoring & Evaluation	0.07	0.165	0.075	0.31
11. Contingencies	0.330	2.855	0.15	3.335
Total	4.5	30.00	1.560	36.060

REPORT

August 1995, Coimbatore
Population and Habit Viability Assessment
P.H.V.A. workshop for Great Indian One-Horned Rhinoceros
Jaldapara, 1993

Section III

Related material



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REPORT

August 1995, Coimbatore
Population and Habit Viability Assessment
P.H.V.A. workshop for Great Indian One-Horned Rhinoceros
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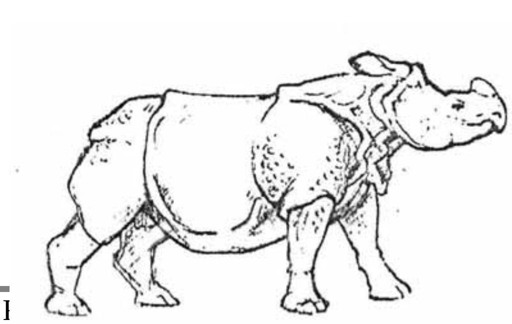
Section IV

CBSG PHVA
Reference Materials



Issues 1. Modeling

What is a Model?

One method for understanding the factors affecting the population extinction process is to use population models. A model is a basic tool used to represent or describe, in a simplified and abstract form, a particulate process of interest. In the case of the PHVA, modeling is a tool that mimics the processes by which populations propagate themselves from one year to the next.

Models can be very simple or extremely complex. Models may seem abstract, only academic, or even threatening. However, we make use of and encounter models in our normal day-to-day activities. Simple models that many of us encounter every day are symbol used in common signs. For example, the male/ female diagrams on toilet doors are in fact simple used to summarize and simplify important information. A more complicated day-to-day model in family financial planni8ng. When we plan for financial saving s or budgets, we : 1) define a financial objective; 2) collect data on our financial situation; 3) analyze the data under different scenarios using simplifying assumptions of real process; 4) evaluate different scenarios; and 5) make a decision. We may do all this in our minds, without the aid of a computer or calculator, but we nevertheless have performed a modeling exercise to come to some conclusions. Population's models are just an extension of this process of complication and analysis of data using a simplified version of real processes. It is important to note that the purpose of the model is not intended to represent realistically and accurately all the processes involved, but to simplify the process sufficiently to gain a better understanding.

A very simple population's model may look like this:

```
-----------
Population
Size 1994
= 100
---------
|
|
\
+10 Births
+3 Immigrants
-7 Deaths
-2 Emigrants
|
|
\
=====
Population
Size 1995
=104
--------
```

This simple process can be repeated years after year to give a basic idea of long-term changes in population size. At a very basic level, all we need for a model of populations projections are data on birth rates, mortality, immigrations, and emigration. This very simple model may be sufficient for some purpose. However, more complex models that consider additional factors that affect population dynamics are more appropriate and useful for the PHVA process.

What is a simulation Model?

A stochastic population simulation model is a kind of model that attempts top to incorporate the uncertainty, randomness or unpredictability of life-history and environmental events into the modeling process. Events whose occurrence is uncertain, unpredictable, and random are called stochastic. Most events is an animal's life have some level of uncertainty. For example, there   usually is a 50/50 chance an individual is a male or female and certain probability that individual will live through one year to the next, mate, reproduce, and produce an uncertain number of offspring. Although we cannot predict exactly what events an individual will experience during its life, we may have a general idea of the range of possibilities for these various events (e.g., on the average an individual may have a 90% chance of surviving from one year to the next, or that little sizes vary from 1 to 4), but individuals vary within that range. Similarly, environmental factors, and their effect on the population process, are stochastic – they are not completely random, but their effects are predictable within certain limits.

Simulation solutions are usually needed for complex models including several stochastic parameters. A simulations model of an animal population mimics actual demographic and genetic events, such as deaths and births, in an explicit time dimension. Both time steps and individuals are usually simulated as discrete and finite. When stochasticity is included in a simulation model, each run may be a unique sequence of events, with different end results in all runs, So, to be able to present both a realizable expected average result, as well as an estimate of expected variations in the result, we need to run the simulations many times, often several thousand times.

Events that are stochastic need to be described in terms of both their average value(mean) and their variance, or standard deviation (a measure of the distribution whichValues can take around their mean). For example, if litter size ranges from 1 to 5 average litter size, may be about 3 and the variance around 1. When modeling the effect of stochastic properties, both the average and variance need to be known.

The vortex model incorporates factors with uncertain outcomes (stochastic factors) by randomly making a decision about what will happen within the limits as specified by the variance associated with that factor. For example, sex determinations of a newborn is determined by the simple process of the computer “flipping a coin” Heads assigns one sex, tails the other. More complicated stochastic events, like the variation in survival rates associated with fluctuations in the environment (both the survival rates and the effect of environment have stochastic properties), are incorporated by the computer flipping m7ultiple “biased” coins (those with probabilities for heads and tails are not 50/50). The coin flipping process is achieved by the computer using random number generation.

Because many of the processes in the population are stochastic, one run (simulation) of the model will result in a different outcome than a second run. One run is no more accurate than another – they simply reflect that might result from normal, expected variation in those stochastic factors that affect the population’s dynamics. There are two levels of stochasticity incorporated throughout much of Vortex: reproduction and mortality stochastic (like a coin toss) and also the probabilities of reproduction and mortality vary over time (like a random selection of the coin to be tossed from a bag of variably biased coins). Thus the of stochastic processes modeled by VORTEX includes both individual survival and annual fluctuations in population survival rates (as distinct levels of stochasticity) and individual reproduction and variable reproductive rates. Also (in contrast to the above) with respect to inbreeding, it is the individual mortality due to inbreeding that is stochastic (i.e., some inbred individuals live, other die, but all have a higher probability of mortality than so non-inbred individuals).

The same in true in real populations: two identical populations exposed to the same conditions will likely have different projections. That is the nature of stochastic effects. One of the purposes of running the stochastic model is to determine how much variation there might be among the average population projections. Therefore, multiple model simulations (perhaps as many several hundred) are needed to show the range, or distribution, of possible outcomes that range of possible values affecting the population.

The processes in VORTEX that have stochastic or random components are:

Sex determination
Individual survival
Survival rates or probability
Reproduction
Reproductive rates or probability reproduction
Number of offspring
Dispersal

Gene transmission
Inbreeding induced mortality
Mate selection
Occurrence of catastrophes
Mortality and loss of due to catastrophes

Why Model?

There are a host of reasons for why simulation modeling is valuable for the PHVA process. The primary advantages, of course, are to simulate scenarios and the impact of numerous variables on the potential of population extinction. Interestingly, not all advantages are related to generating useful management recommendation. The slide-benefits are substantial.

- Population modeling supports consensus and instills ownership and pride during the PHVA process. As groups begin to appreciate the complexity of the problems, they have a tendency to take more ownership of the process and the ultimate recommendations to achieve solutions.

- Population modeling forces discussion on biological aspects and specification of assumptions, data, and goals. The lack of sufficient data of useable quality rapidly becomes apparent and identifies critical factors for further study (driving research), management, and monitoring. This not only influences assumptions, but also the group's goals.

- Population modeling generates credibility by using technology that non-biologically oriented groups can use to relate to population biology and the "real" problems. The acceptance of the computer as a tool for performing repetitive tasks has led to a common ground for persons of diverse backgrounds.

- Populations' modeling explicitly incorporates what we know about dynamics by allowing the simultaneous examination of multiple factors and interactions more than can be considered in analytical models. The ability to alter these parameters in a systematic fashion allows testing a multitude of scenarios that can guide adaptive management strategies.

- Population modeling can be a neutral computer "game" that focuses attention while providing persons of diverse agendas the opportunity to reach consensus on difficult issues.

- Population modeling outcome can be of political value for people in govenmettal agenesis by support for perceived population trends and the need for action. It helps mangers to justify resources allocation for a program to their superiors and budgetary agencies as well as identify areas for intensifying program efforts.

- The VORTEX model analyzes a population in a stochastic and probabilistic fashion. It also makes predictions that are testable in a scientific manner, lending more credibility to the process of using population modeling tools.

Why Use VORTEX (Rather Than Other Simulation Models)?

At the present time, our preferred model for use in the PHVA process is called VORTEX. This model, developed by Lacy et al., is designed specifically for use in the stochastic simulation of the small population/extinction process. It has been developed in collaboration and cooperation with the PHVA process. The model simulates deterministic forces as well as demographic, environmental, and genetic events in relation to their probabilities.

There are other commercial models, but presently they have some limitations such as failing to measure genetic effects, being difficult to use, or failing to model individuals,. VORTEX has been successfully used in more than 70 PHVA workshops in guiding management decisions. VORTEX is general enough for use when dealing with a broad range of species, but specific enough to incorporate most of the important processes. VORTEX is in its sixth version and is continually evolving in conjunction with the PHVA process.

VORTEX has, as do all models, its limitations which may restrict it s utility in some cases. If VORTEX is not considered appropriate, different models should be used. A “tool” kit of simulations models should be developed to enhance the overall process.

Issue 2.   Why Undertake Single Species Conservation?

Management actions aimed at conserving Biodiversity take place at various levels of the biodiversity hierarchy, a nested hierarchy of spatially, taxonomically, and conceptually defined units with often ill-defined boundaries. Conservation problems are manifest at different levels of this hierarchy; for instance, a change in a flooding regime will require action at the ecosystem level, whereas a species-specific problem, (e.g. over harvesting or pathogens) will require action at the species level. Conservation activities focused on any one layer to the bio-spatial hierarchy must take into account linkages to other levels.

(1). The ECOSYSTEM and (2) COMMUNTIES are the most complex and least understood units of conservation management. It generally is acknowledged that extensive protected areas are an effective mechanism for retaining a large proportion of a region's biota. The approaches have been recommended as the foundation for effective conservation planning by the Biodiversity Conversion and Agenda 21. The focus of management is ecological processes (e.g. nutrient flow, water systems, etc.) and composition (e.g., species).

(3) A SPECIES is a relatively discrete and readily recognizable unit of conservation management, and often the unit of national conservation legislation. The species is the traditional focus for the ex situ agencies (e.g., zoos and botanic gardens). The focuses of management are the compositional elements of biodiversity: species and associated genetic diversity. Single species management can be undertaken both ion situ an ex situ, taking into account the demographic and genetic status of the species.

The compositional element so species are (4) POPULATIONS, (5) INDIVISUALS, and (6) GENES, and they are increasingly becoming the focus of targeted management action. As populations of threatened species become increasingly isolated and fragmented, there is an increasing need to manipulate both demographic and genetic dynamics.

The majority of the world's species will be retained through the"coarse filter" approach of habitat conservation, which potentially could conserve all levels in the hierarchy. However, many protected areas will require management because of external influences impacting ecological processes and promoting the loss of species and changes in birth community processes and promoting the loss of species and changes in both community structure and composition. Protected area borders are permeable to diseases, invasive species, poaching, civil unrest, and climate change. Accordingly, a "fine filter" approach I required to catch those species not secured through the priority action of habitat conservation.

Single species management for threatened species can take a variety of forms:

- Protection from invasive organisms and pathogens.
- Habitat modification and management (e.g., prescribed burning or provision of nest boxes).
- Reintroduction or translocation.
- Assisted reproduction.
- Ex situ breeding or propagation, either in-country or abroad.

Species as the compositional unit of a community or ecosystem are a convenient and discrete unit of management, particularly when that taxon is threatened and requires species-specific management. A PHVA provides focus on the species level of the hierarchy and provides a forum top bring all required expertise together to ensure a balanced intergraded approach to species conservation. No one management body or mechanism will be sufficient to deal with the complexities of species conservation and the necessary links to other levels of biodiversity.

Protected areas have been established with the assumption that environmental conditionals and community patterns/composition have been stable for long periods in the past and will continue to be stable into the future. There is increasing evidence that ecological communities are loosely organized collections of species whose co existence depends on their individual's limits and subsequent distribution along environmental gradients. On a geological scale, they could be viewed as relatively transient assemblages.

Species programs, dealing, dealing with single species issues, can be used effectively to promote habitat conservation. Species can be used as flagship (a symbol for conservation), or promoted as keystone (providing a key ecological function) and umbrella species (species requiring large areas of intact habitat) to help conserve of viable habitat reserves. Ex situ species displays, such as zoos and botanic garden, can play a fundamental role in public education and fund raising. Species can provide a diagnostic tool for ecosystem monitoring. In some cases, the development of a single species program has lead subsequently to the development of habitat programs (Florida Panther, red wolf, Costa Rican Squirrel monkey, signal, Sumatran rhino, golden lion tamarin).

However, poorly planned single species management can result in damaging changes in species abundance and can be interpreted as undermining the value of habitat conservation. For instance managing for dense concentrations of valued game or other high profile animals can profoundly degrade a habitat.

Single species management is sometimes accused of focusing on lost causes, however, an increasing number of species dismissed as facing inevitable extinction have survived though often intensive single species management . These include the Arabian Oryx, Asiatic lion, Channel Island black robin, black-footed ferret, Mauritius Kestrel, Sophora toromiro from Easter Island, and Iliamna corei.

There is a need to utilize the most efficient and most appropriate management responses to ensure species survival. The long term conservation of threatened species is dependent on the sustained collaboration between agencies responsible for habitat conservation and single species management, both in situ and ex situ.

Issue 3. INBREEDING DEPRESSION

A simple definition of inbreeding is the production if offspring by related individuals. Inbred individuals have lower levels of heterozygosity, and correspondingly, higher of homozygosis.

Inbreeding depression is defined as the reduction o f fitness (decreased survival, decreased fertility, less diseases resistance, etc) in inbred compared to non-inbred individuals.

There are two general categories in which observable changes of fitness can be correlated with measures of genetic variation:

A. Inbreeding coefficient (often designated as F value) knows and correlated with fitness.
B. Heterozygosity has been measured and correlated with fitness.

There are two possible mechanisms for reduction in fitness when inbreeding increases and heterozygosity decreases:

A. Increased expression of specific recessive deleterious genes (i.e., genes that reduce survival or fertility) which are only expressed when homozygous;
B. The general loss of heterosis (i.e., the advantages of being heterozygous, which can occur even if there are no deleterious genes).

Which mechanism operates in a particular case of inbreeding depression is usually not known, however, the observed effect of inbreeding depression on fitness is what is relevant to assessment of risk to the population.

The smaller the population, the more likely potential mates will be related, resulting in inbreeding. Inbreeding may reduce survival and fertility which in turn, causes the population to become even smaller, increasing inbreeding even more. The result can be an extinction vortex.

There are numerous examples of inbreeding depression in domestic livestock, laboratory animals and zoo populations. There are no published cases of well studied vertebrate species that show a total lack of fitness depression when inbred. Inbreeding depression is less well documented in wild populations because of the difficulty in determining pedigrees for sufficiently long periods of time. However, examples include: Florida panther, Arabian or while Oryx, Mississippi sand hill crane, golden lion tamarin, white tail deer, great tit, and lions isolated in the Ngorongoro crater of Tanzania or the Gir Forest Sanctuary of India.

Although there is significant evidence of a detrimental effect of inbreeding depression, some small, know inbred populations survive. In general, about 95% of rapidly inbred laboratory mice lines go extinct and all efforts to produce inbred livestock line have failed.

A common point is that populations (animal or plant) with a long history of inbreeding, small population size or populations of island species do not necessarily suffer inbreeding depression. Theory suggests that inbred populations may be purged of deleterious genes and, therefore, will not show inbreeding depression when further inbred. Data to support this come primarily from highly inbred laboratory colonies of examples of populations that have been inbred, have a history of small population size, or have low levels of genetic diversity that still show inbreeding depression when further inbred. Inbreeding depression has occurred in the golden lion tamarin, cheetah, przewalski's horse and Pere David's deer (all show low level of genetic diversity). Furthermore, there have been several studies on species of plants that inbreed extensively in the wild (e.g. self-fertilize) but show inbreeding depression when further inbred.

One of the most profound examples if inbreeding in the wild is the Florida panther. The remaining 30-35 individuals show essentially no genetic variation using molecular technology and western pumas as controls. This monomorphic subspecies has documented male sterility, and males consistently produce more than 92% structurally abnormal sperm. In additional to 90% of the males being crypt orchid (one or both testers retained in the body cavity), both genders have a high incidence of cardiac defects and a high seroprevalence to infectious pathogens including feline infectious peritonitis, feline immunodeficiency virus, and rabies.

Another risk for small populations is loss of variations by genetic drift resulting in decreased adaptability to changing environments and increased risk of extinction. This effect is important for the long-term evolutionary violability of the population.

In general, management should avoid inbreeding when there are no other management conflicts. Situations in which management to minimize in breeding depression should be considered include:

A.Establishment of new populations.

1. Selection of founders (non-related, short-term; adequate number and equalization representation, long-term).

2. Inadequate carrying capacity for sufficiently large populations to minimize genetic drift effects.

3. Growth rat of populations so slow that it remains at low numbers over several generations resulting in rapid loss of genetic variation.

B.Management of existing small populations.

1. Population's supplementation with unrelated stock, via translocation or from captivity.

2. Selective removal (harvest) of individual from over-represented lineages (i.e., males that already have produced many offspring).

3. Habitat modification that will increase population's size and decreases its variation (food supplementations, artificial nest-sites, etc.).

4. Optimal out-crossing (e.g. Peregrine falcon, Florida Panther).

C.Management of metapopulation.

1. Gene flow though managed migration of individuals or their individuals.

The effect of inbreeding has considerable relevance to conservation. The numerous studies indication inbreeding depression or correlating loss of fitness with decrease in heterozygosity suggest that there can be significant genetic risks associated with small population size. The risks of inbreeding must be weighed against other types of risks (demographic, catastrophic, etc.) The consequences of ignoring possible genetic risks may be serves. Managers must determine what level of risk is willing to assume.

Suggestions for facilitators

Although it is difficult to assess level of knowledge of the audience, be prepared to elaborate on definitions of terms used in report and introductory lecture. Call upon population biologists for answers to difficult questions on population biology.

Commonly asked questions:

Q : " Inbreeding is not deleterious" or "it's not a problem for my species".
A: Refer to lecture and essays, reiterate level of risk and potential long-term effects from loss of heterozygosity. It may be helpful to use metaphors for risk: example : Some people have survived jumping without a parachute, but I wouldn't suggest it. Use the paper by Roelke et al. (inbreeding effects in the Florida panther) as an example.

Q: "Inbreeding is not a problem because I have adequate numbers in my population
A: Look at effective number of individuals. What is the history of the population (i.e., unequal founder representation) Is it known? The population may be structured in a way that inbreeding is a problem (i.e., subpopulation versus meta population size)

Q: If inbreeding is the only mating option, is there any point in continuing.
A: Even if inbreeding is inevitable, there are management actions to reduce risks (e.g. increasing population size as much and as fast as possible and equalizing founder representation). Because of the increase vulnerability of inbred populations, it may be necessary to reduce (even to unnaturally low levels) the threats and stresses placed on an inbred population, until such time that genetic variation is restored by immigration or mutation.

Slide Presentation/ Lecture Content Suggestions for Inbreeding Discussion:

1). Include examples of inbreeding depression in wild: Florida panther, Arabian oryx, Missisippi sandhill crane, golden lion tamarin, white-tailed deer, great tit.

2). Include examples of small populations that have survived with a discussion of what the insights they offer indicate about genetic risks of small population size. Pere David's deer, deer on grounds of presidential palace in Indonesia, whooping crane, and northern elephant seal. Many breeds of domestic dogs are moderately inbred They survive when coddled, but show many genetic defects. Breeders out-cross them when these defects become life threatening.

3). Stochasticity discussion: Dependent on luck of selection of initial individuals (i.e. some people have survived jumping without a parachute, but is isn't recommended). Discussion of responsibility for assuming risk.

4). Time scope of risks needs to be included. “All populations go extinct eventually”. In the short term, only a few generations may be involved. No guarantees. Only a small % will survive. Will you accept the risk?

5). Emphasize the fact that inbreeding depression is relevant to conservation. Relationship to extinction vortex. Inbreeding is not an alternative explanation for species decline, nor an independent threat, but rather a factor that interacts with demographic and environmental variation. In bred populations have reduced demographic rates and experience greater susceptibility to demographic and environmental fluctuations.

6). Include plant examples (particularly for out breeding)

7). Long term has two issues”

a. Whether you see inbreeding depression
b. Whether loss of variability

Issue 4. Lack of Data

Information shortage is a theme that underlies the entire process and can and will arise at many points. This is both a valid concern, and also one approach to invalidate the entire process. Therefore, it is important to explicitly recognize this concern ad continue to show the value of the totality of the information which is typically found and generated during the process.

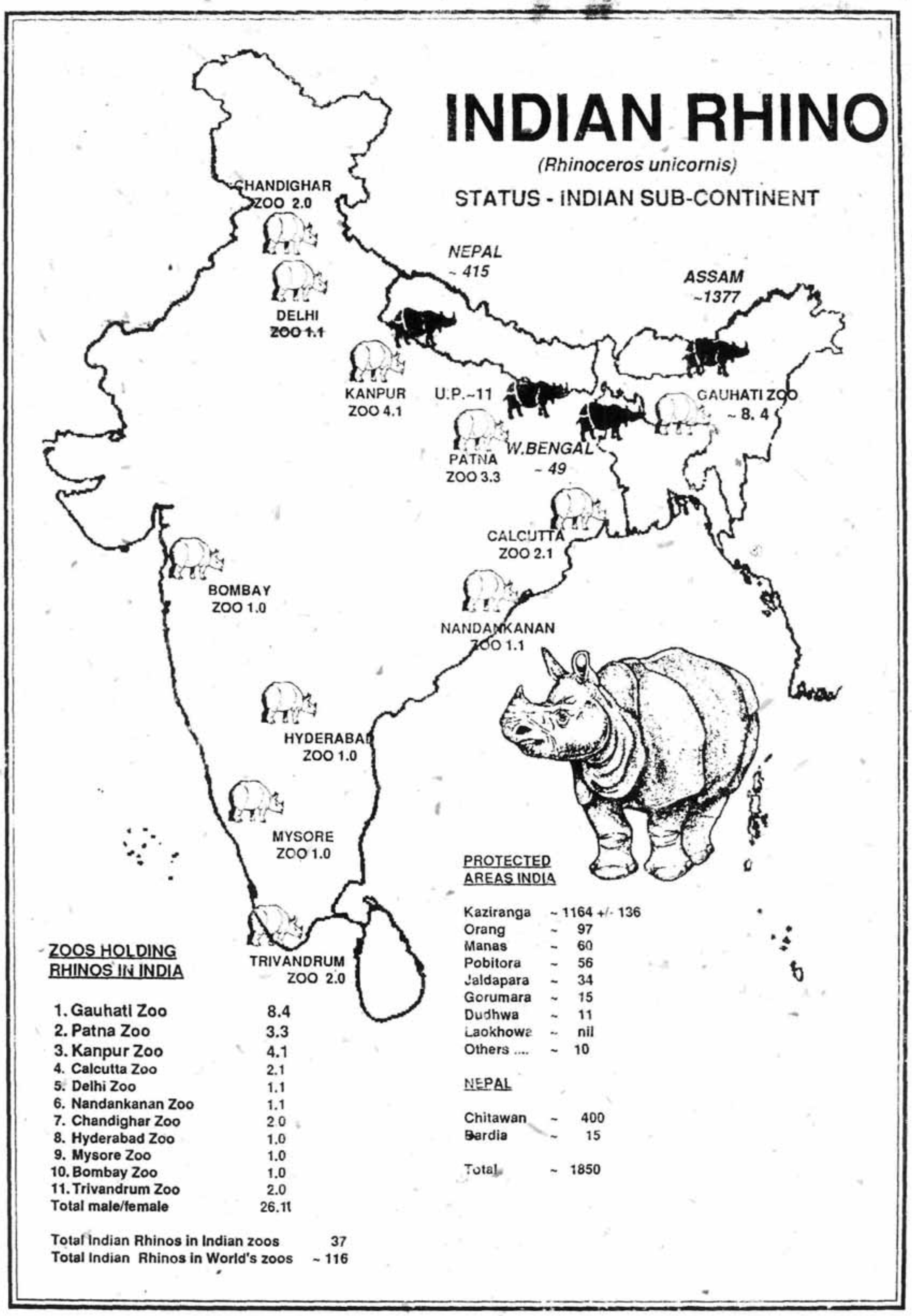
The PHVA Process assembles data uniquely and synergistically - the process of literature review, involvement of all identifiable expert and interested parties, group discussion of the analytical power of this aggregated information, contributions of unpublished data, field notes, etc., and administrator data combined with the audit like process of internal consistency checking validates information or helpfully detects problems. The entire review and modeling provide an objective assessment of the quality of data available from multiple sources. Data which are inadequate in isolation are often found critical and valuable when seen in the context of other data sets. Furthermore, the advance announcement and planning for the workshop stimulate the generation and assembly of additional information. At worst, information and reviewed for its importance through sensitivity analysis.

This integrated and analytical review of data never before assembled coming from many different sources, using knowledge of many individuals and groups on a common ground, has unique power to guide difficult management decisions. Much of the information which typically is mobilized has never before been available to mangers in useful form. The process is a useful means to improve management to minimize extinction risk and minimize regrets while awaiting improved information.

The process generates priorities for information we most need to know, and may suggest that particular or sharper focus should be drawn to planned data collection and research, whereas other data collecting activities may be found les important and can be de-emphasized.

Thus far, on the basis of 75 exercises, there almost always has been enough information resulting from the entire process to provide better guidance to managers than existed before. If this is not the case, the process produces clear priorities for data collection so that they can be carried out systematically.

Because changes and disturbances to the habitat, human and otherwise, do not stop while we may delay analysis or action in pursuit of more information, the decision not to proceed must be recognized as a decision with considerable consequences of its own.


INDIAN RHINO
(Rhinoceros unicornis)
STATUS - INDIAN SUB-CONTINENT
CHANDIGHAR ZOO 2.0
DELHI ZOO 1.1
KANPUR ZOO 4.1
NEPAL ~ 415
ASSAM ~1377
U.P.~11
GAUHATI ZOO ~ 8. 4
W.BENGAL ~ 49
PATNA ZOO 3.3
CALCUTTA ZOO 2.1
BOMBAY ZOO 1.0
NANDANKANAN ZOO 1.1
HYDERABAD ZOO 1.0
MYSORE ZOO 1.0
TRIVANDRUM ZOO 2.0
PROTECTED AREAS INDIA
Kaziranga ~ 1164 +/- 136
Orang ~ 97
Manas ~ 60
Pobitora ~ 56
Jaldapara ~ 34
Gorumara ~ 15
Dudhwa ~ 11
Laokhowa ~ nil
Others .... ~ 10
NEPAL
Chitawan ~ 400
Bardia ~ 15
Total ~ 1850
ZOOS HOLDING RHINOS IN INDIA
1. Gauhati Zoo 8.4
2. Patna Zoo 3.3
3. Kanpur Zoo 4.1
4. Calcutta Zoo 2.1
5. Delhi Zoo 1.1
6. Nandankanan Zoo 1.1
7. Chandighar Zoo 2.0
8. Hyderabad Zoo 1.0
9. Mysore Zoo 1.0
10. Bombay Zoo 1.0
11. Trivandrum Zoo 2.0
Total male/female 26.11
Total Indian Rhinos in Indian zoos 37
Total Indian Rhinos in World's zoos ~ 116