REPORT

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

(Cervus duvauceli)

Produced by

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Population and Habitat Viability Assessment Workshop (P.H.V.A.) for Barasingha *(Cervus duvauceli)*

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BARASINGHA P.H.V.A. WORKSHOP

Executive Summary

The total population of the three named subspecies of barasingha (*Cervus duvauceli duvauceli, C. d. ranjitsinhi, and C. d. branderi)* in India is about 3,500-4,000 animals. It is greatly reduced in range and numbers from historical levels in this century, and the populations are fragmented. All of the populations are below historical numbers and presumed carrying capacities. The species is subject to predation and to poaching in some of the populations. The future of the species in India is contingent upon continued management for conservation of the species. It is listed as endangered by the IUCN Cervid Specialist Group.

The barasingha in India was considered a good candidate for a PHVA Workshop to assist in the process (1) of assembling available information, (2) of bringing together relevant individuals to identify the problem and possible solutions in a common forum, (3) of developing objective models of the individual populations to assess the information and the risk of extinction, and (4) of formulating and testing possible management actions to achieve viable populations. In order to achieve the goal of recovery, it is necessary to understand the risk factors that affect survival of the barasingha. Risk evaluation is a major concern in endangered species management and the goal is to reduce the risk of extinction to an acceptable level. A set of software tools to assist simulation and quantitative evaluation of risk of extinction is available and was used as part of Population and Habitat Viability Assessment Workshop. This PHVA process can improve identification and ranking of risks and can assist assessment of management options.

The Ministry of Environment and Forests requested the Central Zoo Authority to sponsor the Workshop and to coordinate the participation of the Forest Departments of the Range States. The Wildlife Institute of India hosted the Workshop and provided technical expertise in participation. The Conservation Specialist Group of the SSC/IUCN and ZOO/CBSG India were requested to facilitate the Workshop, assemble briefing materials, and to provide technical support.

The Workshop was conducted 3-6 July at the Wildlife Institute of India in Dehra Dun. About 50 biologists, managers, and researchers participated to apply these recently developed procedures to the barasingha. The purpose was to review data from the wild and captive populations as a basis for developing stochastic population simulation models. These models estimate risk of extinction and rates of genetic loss from the interactions of demographic, genetic, and environmental factors as information of value for ongoing management of the subspecies. Other goals included determination of habitat and capacity requirements, role of captive propagation and the management of the captive population, use of translocation and reintroduction to supplement or restore specific populations, impact of predation, poaching, and disease threats, and prioritized research needs.

The first morning and afternoon consisted of a series of inaugural presentations providing an overview on the history and current status of the barasingha in India and the use of the PHVA process in assessing available information and formulating and testing management plans. There were presentations from each of the range states, a review of research information by Qamer Quereshi, and a brief introduction to the PHVA process. This was followed by a brief presentation on population biology, the PHVA process and the use of VORTEX (the computer simulation model used). The model was used to start the collection of parameter values in the plenary session. The participants formed three working groups on the first day (distribution, status, and threats of the free-ranging populations, captive population, and modelling and life history data) to: 1) review in detail current information; 2) develop values for use in the simulation models; and 3) formulate management scenarios and make recommendations. A fourth group on Translocations and Reintroductions was formed on the second day. Stochastic population simulation models were initialized with ranges of values for the key variables to estimate the viability of the wild population using the VORTEX software modelling package.

Census estimates & carrying capacity figures of the various populations of the barasingha

Table 13 : Census estimates & carrying capacity figures of thevarious populations of the barasingha

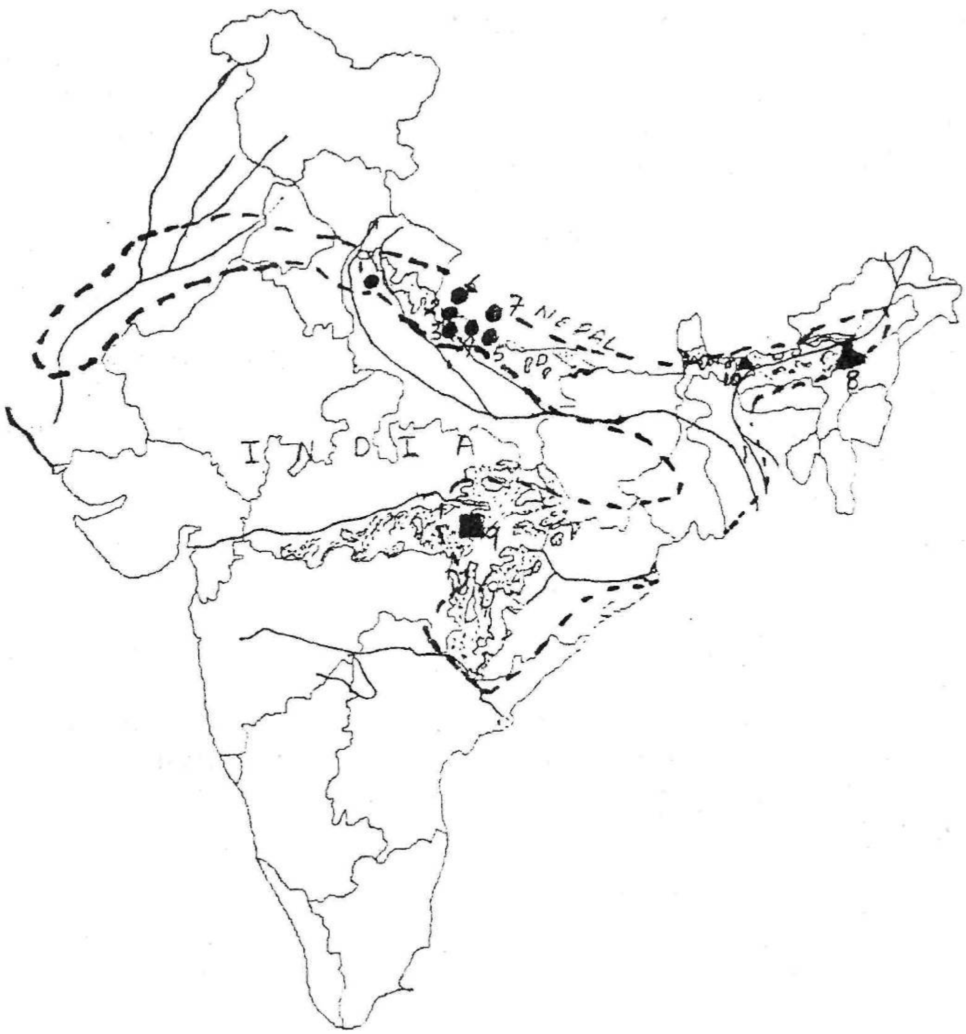
NAME OF POPULATION	PRESENT POPULATION ESTIMATES	MANAGEMENT CAPACITY
Sathiana, UP	125	400
Kakraha, UP	500	700
Bankital, UP	125	200
Bhadhi & Nagraha, UP	100	200
Kishanpur, UP	400	600
Katernighat, UP	50	1000
Pilibhit, UP	200	400
Hastinapur, UP	25	50
Suklaphanta, Indo-Nepal Br	1750	1000
Karnali Bardia, Indo-Nepal Br	50	100
Kanha, MP	366	2000
Manas, Assam	50	100
Kaziranga, Assam	427	800

Based upon a consensus of the participants over the first 2 days of the workshop, the following life history values were selected for the modelling process. The intent was to define the values for a healthy population under favorable ecological conditions. The primary data set is taken from a combination of published work for the Kanha population as well as data from other cervid species when barasingha-specific data were lacking. Age of first production of young was 3 for females and 5 for males. Forty-four percent of females produced one offspring each year. Equal-sex ratio at birth was assumed. Mortality was estimated to produce a population capable of growing as much as 10% per year, which is typical of cervid species with litter sizes of one and alternate year production of young. The four populations in Dudhwa National Park were taken as a special case both because of particularly low female production in one population, and because of the metapopulation structure (some populations can potentially exchange individuals regularly). The sensitivity of barasingha populations to various natural and human-induced factors can be evaluated by changing specific life-history characteristics affected by these factors, and modelling the population projections into the future (in this case 100 years).

A range of values for the effects of predation and poaching on adult mortality were explored to determine their effects on risk of extinction, population growth rates, and as a guide to possible management scenarios. Additional risk factors were also evaluated including disease epidemics and inbreeding depression. Since reintroduction is being considered as a management tool, several scenarios for the establishment of new populations were tested. Separate models were developed to account for the growth characteristics of the captive population, for comparison with values from the wild population, and to determine the impact on heterozygosity of adding new founder stock to the population.

This workshop report includes a set of recommendations for management of the wild and captive populations as well as sections on the distribution and numbers of the wild subpopulations, translocation and reintroduction, and the population biology and simulation modelling of the wild and captive populations.

Distribution of Barasingha *(Cervus duvauceli)* in India and Nepal



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- Cervus duvauceli duvauceli — Northern subspecies
- Cervus duvauceli ranjitsinhi — Eastern subspecies
- Cervus duvauceli branded. — Central subspecies
- ---- Range of distribution

Localities	Population range
Hastinapur	25 - 50
North Pilibhit Division	75 - 3 50
Kishanpur Sanctuary	300 - 450
Dudhwa National Park	600 - 800
Katerniaghat Sanctuary	25 - 50
Suklaphanta Wildlife Reserve (Nepal)	1500 -1700
Karnali - Bardia Wildlife Reserve (Nepal)	50 - 75
Kaziranga National Park	350 - 450
Kanha National Park	300 - 400
Manas National Park	few (??)

Source : Qamar Qureshi,
Wildlife Institute of India

Recommendations

General

1. The main priority for barasingha deer is strengthening the in situ populations to maintain wild populations with long term viability.
2. Information on population trends, threats and protection measures is needed for each of the populations.
3. Develop an international conservation program for barasingha in collaboration with Nepal.
4. A follow up PHVA Workshop should be scheduled in 1-2 years to evaluate progress in implementing recommendations, review new data, revise the models, review and further develop management plans for each individual population.
5. There is need for a 5-year review process for the results of research and implementation of management plans.
6. Continue the taxonomic work on the relationships of the 3 subspecies using molecular DNA technology as well as protein polymorphisms.
7. Translocation and reintroduction of barasingha in India should be done only with animals taken from wild and captive populations in India.
8. Populations need to be monitored for diseases.
9. Ecological monitoring of the barasingha populations is needed.
10. Identify the rutting, fawning and summer grounds for all barasingha populations.
11. Plantations of eucalyptus and teak have to be removed from all barasingha habitats and the habitat should be maintained. .
12. Zoos and Reserves need to give a high priority to conservation education for the barasingha and its habitat.
13. Wildlife extension activities must be carried out near all barasingha areas.
14. There must be better infrastructure and incentives for staff.

Distribution and Census

UTTAR PRADESH

General

15. Pilibhit and West Baharaich Forest Division, being a unique ecosystem for barasingha and other wildlife, need to be brought under the unified command of the wildlife wing.
16. Efficient fire management with studies of effectiveness are needed.
17. Other populations need to receive additional protection.

Sathiana Population (Dudhwa National Park)

18. Create patrol areas ('chowkis') and develop the needed infrastructure at the breeding grounds of the Sathiana population which are outside of the protected area.
19. Develop a management plan for action to be taken if the Sathiana population continues to decline. Translocation, if done, should be to another area in Dudhwa.
20. Renovate the road connecting Bumnagar Chauraha, Sumer Nagar, Kema Gowdi, and Gauri Phanta.
21. The Soheli Barrage floodgates have to be kept open between June and September, during the monsoon. It should be closed between October - May during the winter and summer keeping in mind the safety level.

Kishanpur Wildlife Sanctuary

22. Staff and infrastructure at Kishanpur Wildlife sanctuary need to be built up.
23. There must be a monitoring of the Jhadithal and Ull river areas as the barasingha population is distributed along these.
24. Water needs to be provided during dry summer months to fulfill drinking requirements.

North Pilibhit Forest Division

25. No human settlements must be allowed near Lakkabagha to ensure further protection.

Katernighat Population

26. There must be a control on grazing and a closure of the state seed farm.

Hastinapur Population

27. This population needs to be studied and protected more extensively before any concrete management steps can be recommended.

MADHYA PRADESH

Kanha Population

28. The enclosure that has been made for studying the barasingha breeding needs to be put to use and a small population built up in the enclosure. Care must be taken to manage at levels that reduce the risk of parasite buildup.
29. Efficient use of controlled burning is needed.
30. A few barasingha from Kanha and Mukki need to be relocated to the meadows of Supkhar.
31. The reasons for the conversion of the grasslands from long grass (which provides protection of fawns from jackal predation) to short grass need to be established. There must be a study and monitoring of the intrusion on meadows of woody species and woodland. Appropriate measures, if required, may be taken.
32. Studies to determine the impact of jackal predation on the young of the barasingha are needed (chital fawns are being taken by jackals as well).
33. The effects on barasingha of competition between the large population of chital and the barasingha for food resources needs to be evaluated.

ASSAM

Kaziaranga National Park

34. The cause of the drastic decline in barasingha population between 1991-1993 should be ascertained and future management strategies evolved to mitigate the problem.
35. Ecodevelopment activities for the welfare of the local people and getting necessary cooperation in general and especially during the flood season must be continued.
36. The creation of highlands and soil conservation which has been taken up by the department must be given priority.
37. Patrolling must be intensified especially along the North and the southern areas of Kaziranga during the floods.

38. Anthropogenic pressures on the fawning and rutting grounds and the land use structure must be focused.
39. There must be detailed studies of the barasingha population in Kaziranga.
40. There must be a monitoring of the movement patterns of the barasingha populations in Manas and Kaziranga especially during floods.
41. Manas needs a status survey of the population as no current figures are available from the protected areas.

Population Biology and Modelling

42. Survey and monitoring studies of barasingha populations need to collect census estimates and fawn production rates with an estimate of confidence limits.
43. Annual census estimates are needed for all populations. The census should record as accurately as possible the stage structure of each population.
44. Basic life-table data on stage and sex specific mortality and fecundity rates need to be collected for barasingha.
45. Poaching rates need to be monitored and estimated in these populations.
46. Estimates of population size limits and trends over time for each population are needed.
47. The percent of males actually participating in breeding needs to be known to estimate the effective population size.
48. Studies of migration rates and breeding success of the migrants are needed.

Translocation and Reintroduction

49. The reintroduction of barasingha will be carried out only after suitability of the site is established. The reasons for loss or continued decline of a population need to be established and corrected before translocation or reintroduction programs are begun to re-establish the population at any site. The following four sites are suggested for reintroduction.
50. Reinforce the existing population in the Katerniaghat Wildlife Sanctuary with animals taken from doomed populations considering the IUCN guidelines and as per an approved action plan.
51. Re-establish a population in the Suhagibarua Wildlife Sanctuary either by translocation from wild populations or reintroduction from captive stock or a combination of the sources considering the IUCN guidelines and as per an approved action plan.
52. Reintroduction/Translocation have to be considered in Achanakmar WLS or Baudhargarh NP with resource stock taken from Kanha in a phased manner, on the basis of IUCN guidelines and as per an approved action plan.
53. In Jaldapara WLS of West Bengal, where barasingha were found in recent times, a re-introduction programme can be initiated on an experimental basis following IUCN guidelines and as per an approved action plan.
54. In view of the threats in Kaziranga WLS and Manas Tiger reserve, alternate suitable habitats for barasingha need to be identified, and rescued animals from Kaziranga reintroduced as per an approved action plan and considering IUCN guidelines.

Captive Population

55. Maintain stocks in Indian zoos as standby for possible future conservation needs of the species.

56. Supplement the captive population with genetically unrelated animals from suitable wild populations to increase the proportion of the wild population genetic variation represented in the captive population.

57. Complete DNA studies of the captive population: (1) to establish the amount of heterozygosity retained in the captive population as compared with the wild population, (2) to clarify matters of parentage and pedigree, and (3) to compare with the named subspecies.

58. All captive animals should be permanently marked and a studbook established.

59. Coordinate the genetic and demographic management of the entire captive population in Indian zoos.

60. Establish captive populations of the unrepresented subspecies (as established by DNA studies) as part of a total management strategy for these subspecies.

61. If animals are required for reintroduction programs, develop a collaborative management plan for production of the needed animals while maintaining the viability of the captive population.

62. Develop information on the reproductive biology of barasingha to allow use of assisted reproduction and genome resource banking as part of the conservation management.

REPORT on the P.H.V.A. for Barasingha

Section II. Population Biology and Modelling

Results of Model Runs

II. POPULATION BIOLOGY AND MODELLING

Facilitator: Jon Ballou, Members: Rohan Arthur, Aparijit Dutta, Kavita Isvaran, M. D. Madhusudan, Charudutt Mishra, Sanjay Molur, Divya Mudappa, Suhel Quader, Christy Williams.

Population projection simulation models are useful for evaluating the effects of various natural and human-induced forces on a population's long-term viability. The goal of the population modelling group was to develop and to use a simple model for barasingha populations that could: 1) evaluate the possible effect of threats to specific barasingha populations; 2) to provide an evaluation of the effects of various recommended management actions made during the workshop; and 3) to determine the sensitivity of the population to assumptions made about data that are not available. The model does not, and can not, provide an exact description of all possible processes involved. Rather it is intended to help provide a better basic qualitative understanding of these processes.

The DOS version of the VORTEX model (version 7, Lacy et al. 1995) was used.

Baseline Data

The group first identified a baseline data set of life-history parameters to use for exploring and comparing various management actions and other factors that may affect the populations. It was decided to generate a baseline dataset that represented a healthy, growing population typical of other cervid species. With the potential of producing only one offspring/year, a realistic growth rate is approximately 10%.

1. **Age of first reproduction**
   Age of first reproduction is normally 2 for females and 5 to 6 for males. VORTEX requires the age at which offspring are birthed. To account for gestation, the age at which females give birth was 3. The age of reproduction for males was taken as 5.

2. **Litter size**
   Litter size of females that produced was 1.

3. **Percent of females breeding.**
   There are 12 years of data on fawn/adult female ratios that can be used to calculate percent of females breeding (table 1). These data show that the average percent of females breeding is approximately 40% (SD 9%). The 1964/65 data were not included because during this time in Kanha tigers were baited with barasingha fawns. All populations except the Sathiana in the Dudhwa metapopulation used these values. Sathiana used approximately 36% breeding females (SD 9%). These estimates are based on counts of fawns and females after the period of high neonatal mortality (usually within 30 days of birth). Thus they do not include all births born to females. This has strong implications on the neonatal mortality rate used in the model (see below).

Table I.		
Year	Source	fawn/female ratios
1964	Schaller	.15
1965	Schaller	.16
1971	Martin	.273
1972	Martin	.477
1973	Martin	.361
1974	Panwar	.345
1975	Panwar	.460
1976	Panwar	.500
This Report	Distribution Group Report,	.443
This Report	Distribution Group Report, Suklaphanta data	.457
This Report	Distribution Group Report, Kanha data	.595
This Report	Distribution Group Report, Kaziranga data	.471

4. Percent of Males in Breeding Pool

One estimate from Dudhwa suggested that as few as 12% of the males participated in breeding. However, data from other polygynous cervids show that significantly more males can contribute. We tested the effect of assuming different rates per cent males breeding on both population viability and retention of heterozygosity.

5. Reproductive Longevity

The VORTEX model assumes that all living adult animals are in the breeding pool (i.e., have the potential to breed). Thus, maximum longevity must be defined for the purposes here as maximum reproductive longevity. Maximum reproductive longevity was estimated to be 12 years for females. This is similar to data on other cervids (e.g., McCullough, tule elk).

6. Mortality

Estimates of neonatal mortality were available from data on the Kanha population. These data suggest that mortality rate of neonates (ages 0-1) was approximately 34%. However, data on female fecundity (fawn/female ratios) were collected after the period of high early neonatal mortality (usually within the first 30 days of life). Thus, the first-year mortality rates in the model must not include the usually high neonatal rates because this is already incorporated in the female fecundity rates. We used a first year mortality rate of 5% to account for the mortality from the time of fawn count to the end of the first year. This in combination with the 34% mortality seen in the Kanha population results in a total first year mortality of about 62%, which is the same as the first year mortality observed in elk (McCullough 1969).

Estimates of other mortality data were not available for other age classes. However, the following life-table was chosen to represent the barasingha life-history:

Table 2		
Age Class	Males qx (SD)	Females qx (SD)
0-1	.05(.02)	.05 (.02)
1-2	.04(.01)	.04(.01)
2-3	.03 (.01)	.03 (.01)
3-4	.02 (.01)	.02 (.01)
4-5	"	.10 (.03)
5-6	"	"
6-7	"	"
7-8	"	"
.	"	"
.	"	"
12	1.0	1.00

The mortality rates in the post-neonatal age classes were chosen as follows: rates for females ages 1 through 3 were taken from those for tule elk (McCull-ough); females ages 3 through 12 were selected to give the population growth rate of about 9%/year (using the rates of tule elk resulted in negative population growth rates for the amount of fecundity found in this population, so they were not used); male rates were chosen to match females for ages 1 to 4. Higher male adult mortality was chosen to model the higher mortality often observed in cervids as males reach and achieve sexual maturity. The specific rates were selected to result in a male-to-female ratio of about 1:2, which is the observed sex ratio of barasingha (see Distribution Group report).

Standard deviations on mortality rates were generally chosen as 33% of the estimated rate. This was used because it was felt that the range + standard deviation (which should encompass 64% of the observed occurrences of the rate of interest) represented a realistically flexible range for the purposes here. There are no observed estimates for these values.

Metapopulation Structure of the Dudhwa Population

The Dudhwa National Park contains 4 populations of barasingha: Sathiana, Kakraha, Bankital and Bhadhi & Nagraha (see Table 13, Distribution Section). The Sathiana population has declined significantly over the last two decades, and it is estimated that the fawn/female ratio is only 16% as opposed to the 44% used for the other populations.

The reason for this low reproductive rate is that the breeding grounds are outside of the protected areas. Breeding animals are thus exposed to increased poaching pressures. Although data do not exist, it is thought that there is some gene flow among the Dudhwa populations because of their proximity. Therefore we considered Dudhwa a metapopulation with the migration patterns shown in Table 3.

Table 3. Dudhwa Migration Matrix (Migration rates among Dudhwa subpopulations).

Migration Rate To Population:

Baseline Results (from VORTEX)

	Population	Sathiana	Kakraha	Bankital	Bhadital Nagaraha
From Population	Sathiana	-	0.10	0.00	0.00
	Kakraha	0.00	-	0.09	0.04
	Bankital	0.00	0.09	-	0.04
	Bhadhi & Nagraha	0.00	0.04	0.04	-

The baseline data described above results in the following deterministic values. Deterministic population growth rate (based on females, with assumptions of no limitation of mates, no density dependence, and no inbreeding depression):

r = 0.082 lambda = 1.09 Ro = 1.780

Generation time for: females = 7.00 males = 7.75

Stable age distribution:

Age class	Females	Males
0	0.075	0.075
1	0.066	0.066
2	0.058	0.058
3	0.052	0.052
4	0.047	0.043
5	0.042	0.036
6	0.038	0.030
7	0.035	0.025
8	0.031	0.020
9	0.028	0.017
10	0.025	0.014
11	0.023	0.012
12	0.021	0.010

Ratio of adult (>= 5 years) males to adult (>= 3 years) females: 0.474
These results are similar to those observed in other cervid populations.

Results of Model Runs

Effect of Poaching and Predation on Population Persistence

Data on the census size and estimate of carrying capacity for each barasingha population was provided by the Distribution Working Group (see Table 13 of the Distribution Section). Also provided was the estimated per cent of adult animals in each population taken each year by poaching and predation.

To determine the relative impacts of poaching and predation on population persistence, we modelled each population for 100 years both with and without the predation/poaching effects. Models were based on simulations of 500 replications. The predation and poaching effects were included by increasing percent adult mortality in the baseline model by the summed total of the predation and poaching mortality. The results are presented in Table 4 (no predation/poaching) and Table 5 (with predation/poaching).

Under these baseline conditions, all populations had zero probability of extinction except two: the smallest (Hastinapur, N=25, table 4a) and Santhiana in Dudhwa, the one with the lowest female fecundity (table 4b).

Table 4a. Barasingha populations with no poaching or predation.

Population	r	SD(r)	P(E)	N	SD(N)	HET	TE	N (K)
Hastinapur	0.078	0.073	0	49.4	2.7	65.8	0	25 (50)
Kanha	0.082	0.041	0	1999	14.6	98.5	0	366 (2000)
Karnali-Bardia	0.080	0.058	0	99.6	3.1	77.1	0	50 (100)
Katarniaghat	0.081	0.045	0	998.5	9.85	92.8	0	50 (1000)
Kishanpur	0.082	0.043	0	599.7	7.85	96.1	0	400 (600)
Pilibhit	0.082	0.045	0	400	5.34	93.7	0	200 (400)
Suklaphanta	0.081	0.044	0	1007	9.84	97.8	0	1750 (1000)
Manas	0.081	0.058	0	97.6	3.3	78.2	-	50 (100)
Kaziranga	0.082	0.042	0	799	8.8	97.0	-	427 (800)

r Average stochastic r
SDr Standard deviation of stochastic r
P(E) Probability of Extinction by 100 years
N Average population size of surviving populations at year 100
SD(N) Standard deviation of surviving populations size at year 100
HET % retained expected heterozygosity at year 100
TE Median time to extinction
N(K) Starting population size (N) and VORTEX carrying capacity (K)

Table 4b. The Dudhwa Population with no poaching or predation.

Population	N (K)	r	P(E)	TE (Median)	TE (Median)	Final N (SD)
Sathiana	125 (613)	-0.057	0.98	53	54.78 (13.97)	6.33 (3.67)
Kakraha	500 (1350)	0.082	0	-	-	504.58 (67.47)
Bankithal	125	0.082	0	-	-	199.64 (6.12)
Bhadhi& Nagraha	100 (552)	0.082	0	-	-	199.86 (5.30)

Metapopulation total N = 904.16 (SD 68.71) for successful cases.

Table 5a. Barasingha populations with the reported levels of poaching and predators.

Population	r	SD(r)	P(E)	N	SD(N)	HET	TE
Hastinapur	0.068	0.069	0	49.25	2.71	66.80	0
Kanha	0.002	0.038	0	1998.28	14.96	98.58	0
Karnali-Bardia	0.049	0.059	0	98.86	4.48	80.30	0
Katarniaghat	0.049	0.048	0	996.64	25.61	90.85	0
Kishanpur	0.050	0.042	0	597.29	9.75	96.58	0
Pilibhit	0.050	0.044	0	398.51	6.61	94.55	0
Suklaphanta	0.050	0.041	0	818.73	14.21	97.63	0

Table 5b. The Dudha metapopulation with reported levels of predation and poaching.

Population	r	P (E)	TE (median)	TE (mean, SD)	N Popn. size (SD)
Sathiana	-0.158	1.0	14	14.37 (2.95)	0
Kakraha	0.011	0	—	—	212.16 (25.45)
Bankithal	0.011	0	—	—	190.26 (12.26)
Bhadital-Nagraha	0.042	0	--	—	195.96 (7.47)

Metapopulation total N = 598.36 (SD 31.54)

Even with the reported levels of poaching and predation, all but the smallest population and Sathiana seem still to be safe from extinction due to poaching and predation. This suggests that under the conditions of this model, reproduction and survival are sufficient to tolerate this level of poaching and still maintain a positive growth rate.

Effect of Increased Poaching and Predation

We examined a higher rate of poaching to determine if the threat of increased poaching was considered a potential threat to the populations. The amount of poaching and predation for each population is given in Tables 6a and 6b. For the non-Dudhwa populations, 5 of the 8 population have negative r values, indicating that additional poaching at this level is high enough to cause population decline. Two of these 5 showed high probabilities of extinction. The other 3 population sizes at 100 years were significantly below the carrying capacity (see Table 4a), indicating that the populations were still declining but that the rate of decline was not enough to cause extinction by 100 years.

These results indicate that the populations are highly sensitive to extreme levels of poaching and predation. While predation is part of the natural ecology of these species, abnormally high levels due to, for example, lack of other prey species, will jeopardize the population, as will high poaching levels. Predation and poaching should be monitored.

Table 6a. Effect of high poaching and predation rates on non-Dudhwa populations.

Population	% Pred % Poach	r	SD (r)	P (E)	N	SD (N)	HET	TE
Hastinapur	0% 10 %	-0.048	0.175	0.92	18.2	11.1	49.31	42
Kanha	10 % 0 %	0.036	0.043	0	1986	32.8	98.2	0
Karnali-Bardia	10% 7.5%	0.022	0.126	0.5	32.8	22.8	59.75	100
Katarniaghat	10% 7.5%	-0.023	0.125	0.49	33.2	378.0	60.19	0
Kishanpur	10% 2.5%	0.021	0.041	0	586.1	25.2	96.46	0
Pilibhit	10% 7.5%	-0.013	0.076	0.05	87.7	66.9	79.98	0
Suklaphanta	10% 7.5%	-0.011	0.06	0	315.7	166.3	95.08	0
Manas	No data	-	--	-	-	-	-	-
Kaziranga	No data	-	-	-	-	-	-	-

Table 6b. Effect of high poaching and predation rates on the Dudhwa metapopulation.

Population	Stochastic (r)	SD(r)	P(E)	N	SD(N)	HET	T(E) Median
Sathiana	-0.309	0.237	1.0	-	-	-	14
Kakraha	-0.008	0.061	0.0	217.20	32.32	95.96	-
Bankithal	0.040	0.071	0.0	191.25	13.23	95.96	-
Bhaital & Nagraha	0.022	0.068	0.0	185.55	16.94	95.81	-

Effect of Per Cent of Males Breeding On Effective Population Size

Two estimates of the per cent of adult males breeding were provided: 12% and 100%. The percent of males breeding influences the effective size of the population (Ne) and hence the loss of genetic diversity, which in turn affects population viability, if inbreeding depression is present. In addition, when population sizes are low, lack of breeding males may limit reproduction in females. The effect of these two assumptions on the effective size of the population was modelled by creating a hypothetical population of 100 individuals and projecting the population for 100 years (13.6 generations). The level of gene diversity over the 100 year time period was recorded.

Assuming 100% Adult Males Breed: Gene diversity retained = 88.14%

Assuming 12% Adult Males Breed: Gene diversity retained = 77.35%

Ne can be estimated as: $Ne = l/\{2 [1-H_t^{(1/T)}] \}$

When 100% males breed, Ne = 53, and Ne/N = .53

When 12% males breed, Ne = 26, and Ne/N = .26

There is a two fold difference in the Ne/N ratios depending on the % males breeding. In smaller sized populations, this can result in a significant difference in genetic diversity retained in the population. It would be useful to have a better estimate of the % of males breeding in order to determine how susceptible small populations are to inbreeding depression.

Does the Per Cent of Males Breeding Effect Viability When there is Inbreeding Depression?

The effective population size when 12% of the males are breeding is about 50% of the size when 100% of the males are breeding (see above). Does this difference have an effect on population viability when inbreeding depression is considered?

We compared population viability for the two estimates of per cent of male breeding both with and without inbreeding depression. Inbreeding depression was assumed to be typical levels seen in other species, approximately 3.14 lethal equivalents (Ralls et al, 1988). The simulations were done in a population size of 100 animals with a carrying capacity of 100. Baseline life-table parameters were used, but a typical level of poaching (2% adult mortality) and predation (3.5%) were added to adult mortality.

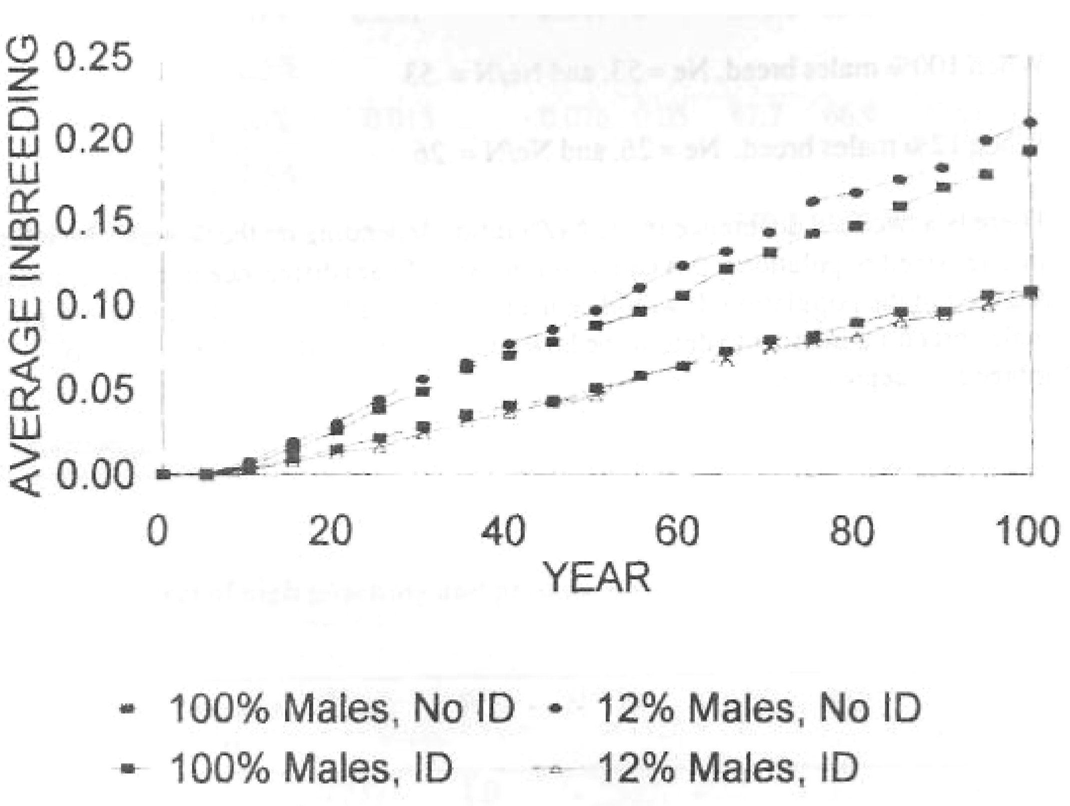


Figure 1. With only 12 % of the males breeding the average levels of inbreeding in the population reached about 0.20, which is only slightly lower than the level of half-sibs (0.25). With 100% of the males breeding, the levels reach only 0.10. The inclusion of inbreeding depression seems to have only a minimum effect on the level of inbreeding when 12% of the males breed.

Figure 2 shows the average population size over the 200 simulations for all 4 scenarios. With 100% males breeding and inbreeding depression, average population size at 100 years is 93 (*SD* - 9.5), while if 12% of the males are breeding, the size is 85 (SD = 15.5). Although there does appear to be an effect of inbreeding on overall population size, it does not amount to a substantial difference over this long time period. In no cases were there any population extinctions.

These results suggest that the normal reproductive and survival rates of barasingha in this particular modelling scenario were high enough to avoid drastic population decline when normal levels of inbreeding effects were imposed on the population. Even in smaller populations (N-50), inbreeding depression is not sufficiently severe to cause population decline.

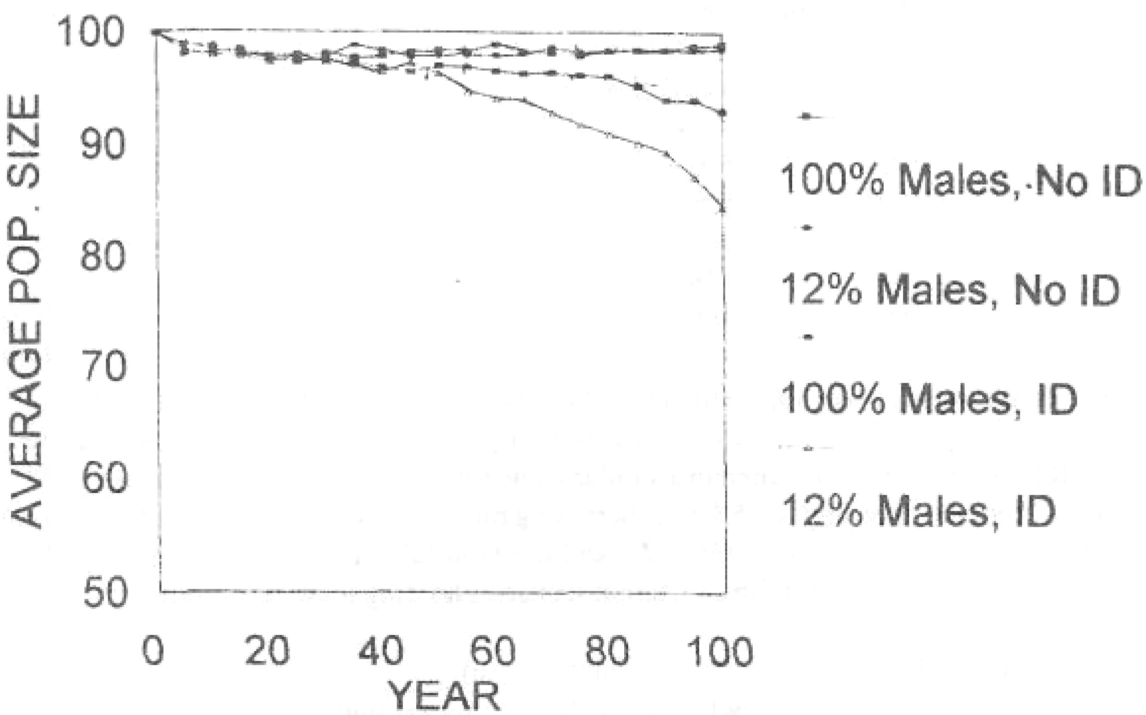


Fig. 2

Effect of Declining Carrying Capacity on Population Viability in Kanha. (D. Mudappa and R. Arthur).

The quality and quantity of habitat available to the species can loosely reflect carrying capacity (K), which, put simply, is the maximum number of animals an area can support. K can change for many reasons, including competition or a change in the quality of the habitat. We modelled the effects of a decline in K for the Kanha population.

Since 1990, the population has been declining. To incorporate this trend into the model, we first calculated a deterministic r for this population using data from the management plan.

The numbers of barasingha were:

Year	# Animals
1990	500
1991	525
1992	441
1993	436
1994	366

The deterministic r was approximately -0.08. We modified the baseline data in the model (as explained earlier), by varying mortality and female fertility rates, so that the VORTEX simulations resulted in a similar value for r. This required decreasing per cent of females breeding to 25% and increasing mortality as follows: of age 0-1 year to 19%, pre-reproductive mortality by 2% and adult mortality to 12% for both sexes. We then ran the simulation for three different scenarios holding these rates constant:

A: K = 366 (i.e. current population size)

B: K = 450 (somewhat below the recent maximum)

C: K = 366, with a 2% decrease per year for 10 years (this was done since weeds are thought to be taking over barasingha habitat)

The results for these three scenarios (500 iterations over 100 years) are illustrated in Table 7. There is little difference between the three. In all three cases, the population shows the same pattern of decrease over time (Figure 3).

Table7. Results of Three Scenarios.

K	r	SD(r)	P(E)	Pop. size	SD(N)	Hetero	TE (Median)
A	-0.088	0.144	0.994	4.33	2.52	20.07	58
B	-0.090	0.145	0.996	2.5	0.71	53.47	57
C	-0.089	0.146	0.996	2.5	0.71	18.75	57

Note : The three scenarios, A, B, and C are as described above.

These results are not surprising. Since the population is declining anyway, raising the carrying capacity has no effect on the population size in 100 years. Again, since the rate of decrease in the population is greater than the rate of decrease in carrying capacity modelled, this does not make a difference either. Clearly, given the current situation, we might expect the Kanha population to go to extinction in 30 to 60 years unless the trend is reversed. (Figure 3).

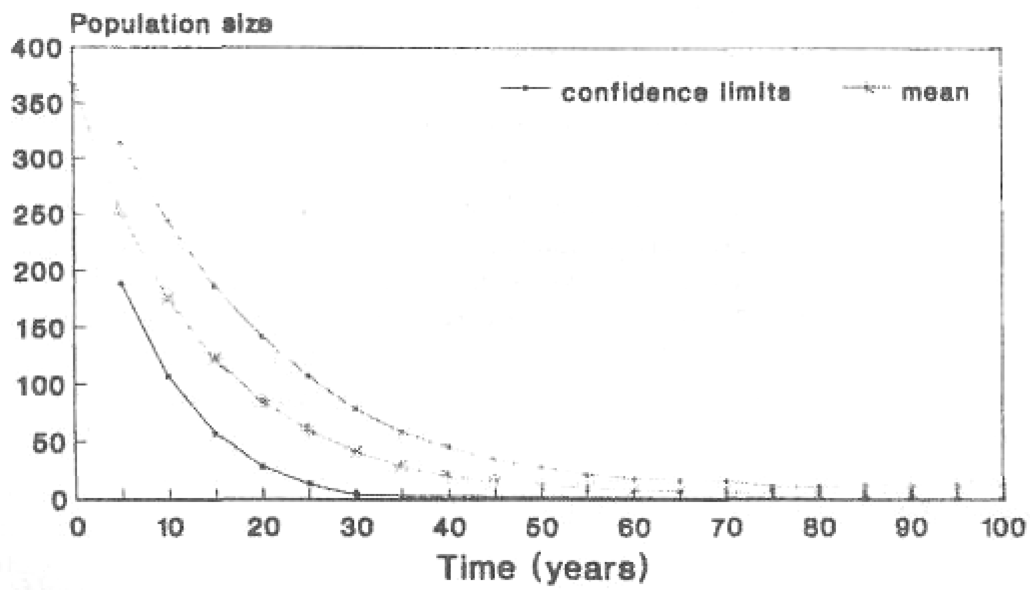


Fig.3. Trends in population size for Kanha with a fixed carrying capacity of 366 (Scenario A). The graph i the same for all scenarios discussed. Confidence limits =/-1.96 SD.

Before taking the usual recommended management measures (like habitat improvement), it is essential to pinpoint the exact reasons for this trend in population decline. On the other hand, the decline may, in fact, be due to a constant decrease in K, and we simply may be limited in our ability to guess accurately at the carrying capacity of Kanha. The cause of the population decline needs to be determined. One suggestion is that the declining numbers may be due to a high level of fawn predation by jackals.

Dudhwa National Park Metapopulation Model

(Charudutt Mishra.Aparajita Datta. and Oamar Oureshi)

Introduction

We projected the population trends for 5 barasingha areas in Dudhwa. Of special interest was the Sathiana population which is declining. The Distribution and Census group has recommended that barasingha from this area be translocated once the population falls to 75. We investigated when this translocation might have to be started given the same rate of decline.

Methods

From the census figures available for Dudhwa over a period of time, we calculated the deterministic rate of growth (r) using the formula:

$$N_t = N_0 e^{n}$$

where N_0= Number of barasingha during the earlier census
N^t= Number of barasingha during a later census r = Deterministic rate of growth t = Time in years between the two censuses

Where census figures were available for several years, we averaged r over all the time periods. For both Kakraha and Bandhit and Nagra, the census figures showed an r of 0,06. We assumed the same for Jhadital and Bhadhi & Nagra, for which regular census figures were lacking. For all populations except Sathiana, the adult mortality was kept at a constant of 7.5 % (SD 2.5). We ran the simulation several times (50 iterations each time) for 50-100 years, each time varying the per cent of adult females giving birth (every year). The simulation where the deterministic r calculated by the model best approximated the actual r (calculated from census figures) was used to project the population trend. The r calculated by the model best approximated the r from census figures when the per cent of adult females giving birth was adjusted to 49% for each of the populations (except Sathiana).

Biologists who have worked in Dudhwa suspected that the Sathiana subpopulation undergoes relatively higher levels of poaching because a part of the barasingha range lies outside the National Park area. Adult mortality in this case was increased to 20% (SD=3.33). The **r** calculated by the model approximated the r from census figures (-0.123) when the % adult females giving birth was reduced to 28. Biologists confirmed that the % adult females giving birth every year in Sathiana is lower compared to the other populations. (In an especially bad year, this was estimated as 16%.)

Results

All populations except Sathiana show an encouraging trend.

Fig. 4a
Jhadital: Census figures show a population of 274 for Jhadital in 1939. Keeping this as the initial population, the model predicts a population of 506 by the year 1999 (Fig. 4a). By the year 2014, the population is expected to approach the specified carrying capacity of 800 (assuming density independent reproduction and survivorship). The probability of extinction in 100 years is **0.**

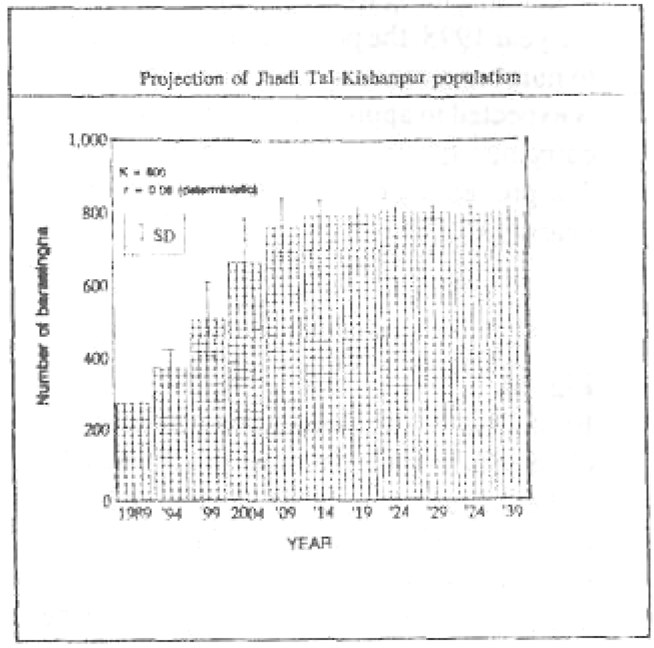


Fig. 4b.
Kakraha: We modelled this population with an initial population of 221, which is the census figure for 1981. By the turn of the century, the population **is** expected to number more than 600. By the year 2010, this population is expected to approach the estimated carrying capacity of 700. The probability of extinction is 0.

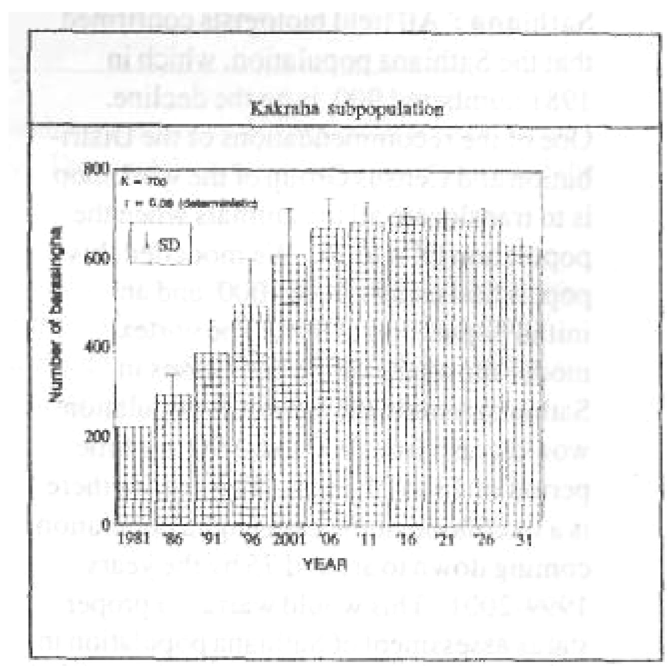


Fig. 4c.

Bhadhi and Nagra : We modelled this population with an initial number of 50, which was the census figure for 1988. By the year 1998, the population is expected to number more than 150. The population is expected to approach the estimated carrying capacity of 200 by the year 2008. The probability of extinction is 0.00 for 50 years (Table 8).

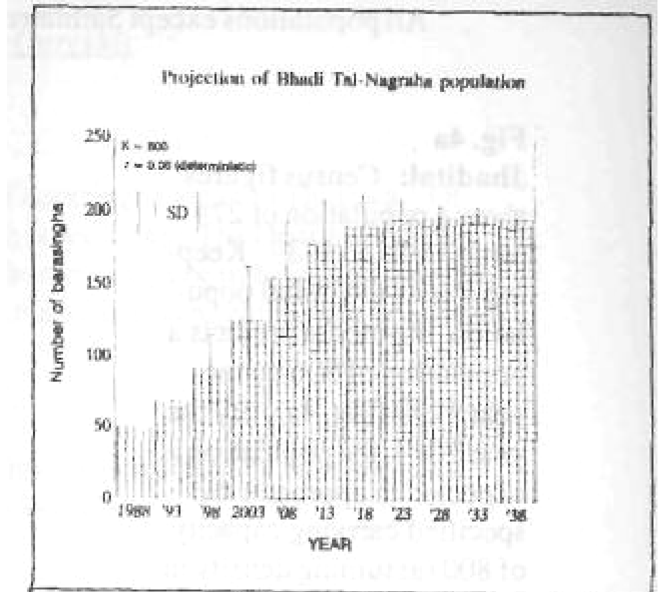


Fig.4d.

Banki Tal : This population was modelled with an initial number of 100, which is the census figure for 1988. By the turn of the century, Bankital population is estimated to go up to about 175 (Fig. 5d). The population is expected to approach the specified carrying capacity of 200 by year 2003. The probability of extinction is 0.

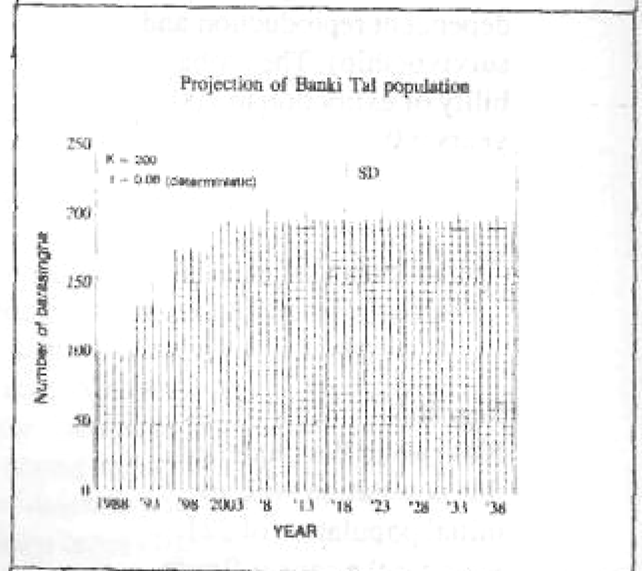
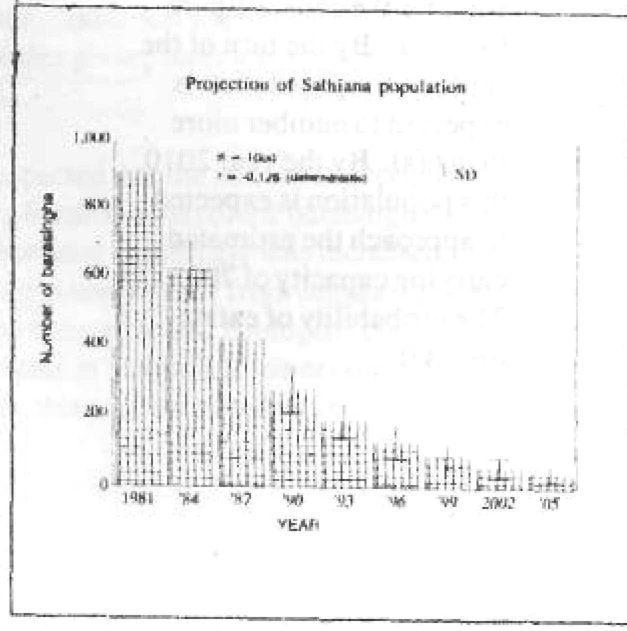


Fig. 4e.

Sathiana: All field biologists confirmed that the Sathiana population, which in 1981 numbered 900, is on the decline. One of the recommendations of the Distribution and Census Group of the workshop is to translocate all the animals when the population falls to 75. We modelled this population using a K of 1000, and an initial population of 900. The vortex model shows that if the conditions in Sathiana remain the same, the population would crash from 900 to 60-90 in a time period of 18 to 21 years. This means there is a likelihood of the barasingha population coming down to around 75 by the years 1999-2001. This would warrant a proper status assessment of Sathiana population in 1999. However, if the standard deviation in the projected populations is considered, the lower limit falls to 80 by the year 1996,



Therefore, we recommend that a thorough assessment of the status of this population be carried out every year from 1996 onward. In addition, because of the likelihood that the population might drop to 75 by 1996/97, plans for translocation, if that is the intent, should begin immediately. The relocation might have to be started before the turn of the century. The projected decline is conservative since inbreeding depression has not been included in the model. Left to itself under present conditions, the population is almost certain to go extinct within 100 years, the probability of extinction being 0.92 (Table 8).

Table 8. Projections of Dudhwa barasingha populations. Adult mortality was keptconstant at 20% for Sathiana and 7.5% for the other populations. The % females giving birth was adjusted such that the deterministic r calculated by the model best approximated the r calculated from census figures. (50 simulations for 100 years).

Population	Stochastic (r)	SD(r)	P(E)	N	SD(N)	HET	T(E) Median
Sathiana	-0.152	0.170	0.92	3.5	1	67.89	40
Kakraha	0.055	0.06	0.0	694.26	18.50	96.14	-
Bankithal	0.055	0.065	0.0	197.88	5.13	88.69	-
Bhadhi Nagra	0.058	0.067	0.0	198.46	5.10	85.66	-
Jhadital-Kishanpur	0.059	0.058	0.0	791.18	24.68	96.86	-

The population figures projected by the model were cross-checked with actual census figures. In all cases these matched closely. The model consistently underestimated the population by about 10 to 25 animals.

All these projections, however, should only be used as very rough guidelines for management. No model can account for the complexities which operate within natural systems. This is especially true for the barasingha, where the biology of the animal is still not properly understood, and even accurate demographic data is lacking.

Success of Founding a New **Population Under Different Translocation Scenarios**

The Translocation and Reintroduction Group recommended examining the effect of different translocation strategies on the success rate of translocations. It was assumed that the translocations would be to highly suitable habitat which would not impose any external constraints on population growth (e.g., no poaching or predation).

It was recommended that the model consider founding a population with 2 males and 5 females (notation used for this combination is 2.5) in the first year, 2.5 in the third year, and 1.4 in the fifth year. VORTEX can model a periodic supplementation of animals in specific age and sex classes, but requires that the age/sex structure of each supplement episode be identical. Therefore the exact scenario of interest could not be modelled.

However, we modelled 3 situations:

	Supplement	Year
Scenario 1:	2.5	1
	2.5	3
	2.5	5
Scenario 2:	2.5	1
	1.4	3
	1.4	5
Scenario 3:	2.5	1
	2.5	3
	2.5	5

But also harvest 1.1 adults in year 5

Scenario 1 over-estimates the desired scenario while Scenario 2 underestimates it. Scenario 3 was an attempt to "trick" VORTEX to match the scenario by supplementing the population in the fifth year with 2.5 animals, but then on the same year harvest (remove) 1.1 animals. Unfortunately, VORTEX will not necessarily remove the 1.1 animals from those added in the fifth year, but will randomly pick 1.1 from among all the surviving adults in the fifth year.

An initial examination of the results showed that scenario 3 fell almost exactly intermediate of the first two (as expected).

Table 9.

Scenario	r	SD (r)	P (E)	N	SD (N)	Het	TE	-
1	0.125	0.099	0	100.49	22.83		94.82	-
2	0.125	0.098	0	85.43	24.33		93.23	-
3	0.125	0.100	0	94.17	22.42		94.74	-
4	0.119	0.098	0	86.38	19.88		91.22	-

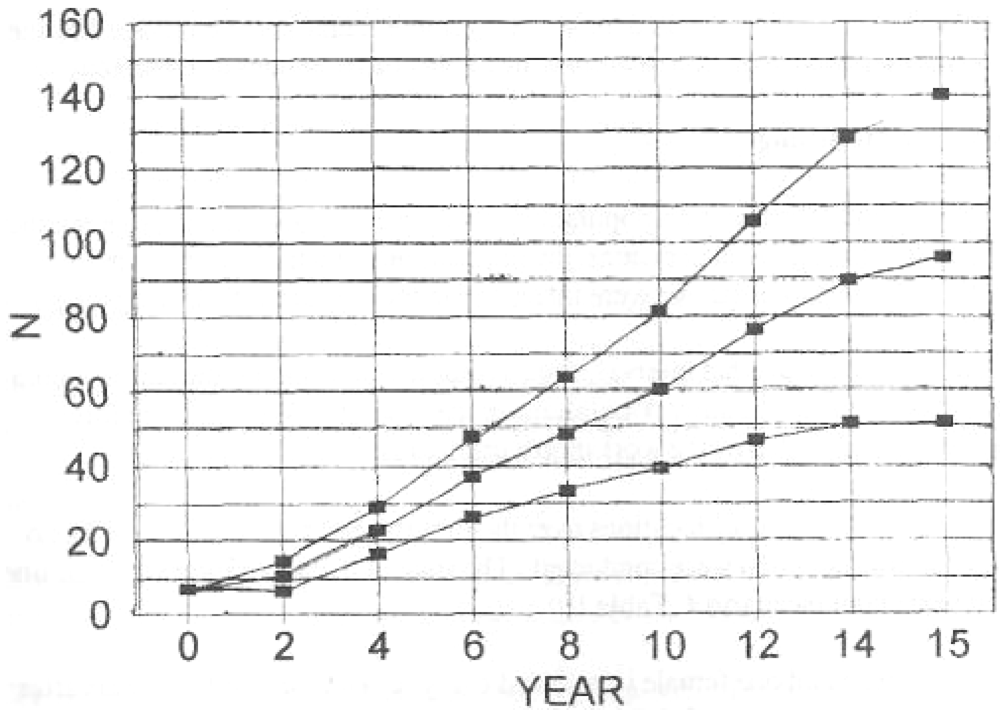


Figure 5

Figure 5 shows that the population grows rapidly and that the probability of extinction is zero under all three scenarios. However, the 95% prediction intervals show that the population size might vary significantly over this time. Also, in all three scenarios, about 5-6% of the heterozygosity has already been lost over this 2-generation time period. If inbreeding depression is also considered, (at a level typically seen in mammals, i.e., lethal equivalents = 3.14), even more heterozygosity is lost because the observed growth rate is reduced.

The average relatedness among individuals in the population is at the level of first cousin, and will increase over time. This level of genetic diversity (94.7% retained) is equivalent to the level in a population founded by only 9-10 founders. Although a total of 19 founders have been translocated, the genetic contribution of only 9 (50%) has already been lost. This low retention of diversity over such a short time period suggests that additional translocated animals are needed to exchange genetic diversity. Various strategies for doing this are examined in the following section.

Translocation and Harvesting
Members: *M. D. Madhusudan, Rohan Arthur, & Divya Mudappa).*

Introduction.

During the course of discussions, biologists and field-managers felt it imperative that a separate population of barasingha be maintained in a small meadow in Kanha. This new population would be supplemented at regular intervals with individuals from the main Kanha meadow. We modelled these management scenarios as envisaged by the workshop participants, in order to examine the likely consequences of these actions.

Questions For Modelling

Starting and maintaining a population of animals in a new area raises a number of questions and management decisions, the implications of which can be simulated using VORTEX. In particular, we were interested in looking at the following issues:

1. How many animals, at what interval, and in what sex ratio should the supplementa tions consist of, to ensure healthy populations in the new site? We modelled three situations as recommended by the workshop participants.

    i. After the initial translocations over the first five years (see section VII), no further translocation were conducted. The state of the population was examined 50 years later (scenario 1, Table 10).

    ii. One male and one female introduced every seven years for fifty years after initial introductions of 2:5 (M:F), 2:5 and 1:4 every two years for five years (see previous section). The simulations of this initial introduction done earlier indicated that the population after seven years would average 37 animals (scenario 2, Table 10).

    iii. Two males and one female introduced every seven years for fifty years after these initial introductions as above (scenario 3, Table 10).

2. Translocations from the main Kanha meadow population for supplementation, would doubtless have a consequence on this population. Can this population, already beset with its own demographic problems, sustain this constant harvesting? In particular, we looked at the effect of harvesting this population under the following conditions.

    i. Assuming a carrying capacity (K), of 500 animals.
    ii. Assuming a carrying capacity (K), of 366 animals.
    iii. Assuming a carrying capacity (K), of 366 animals, decreasing at the rate of 2% for the next ten years.

Results

Table 10: The growth of an introduced population in Kanha Tiger Reserve with different rates of supplementation

Attributes	Scenario 2	Scenario 3
Rate of growth r(SD)	0.087 (0.057)	0.095(0.057)
Probability of extinction	0	0
Expected heterozygosity	91.18	92.19
Time to extinction (median)	0	0
Carrying capacity (K)	200	200
Initial population	37	37
Final population	200	200

Scenario 2: The first scenario envisages a situation in which the initial population of 37 animals (derived from an earlier introduced stock) is supplemented every 7 years with a single adult male and a single adult female. This supplementation is assumed to continue for a period of 50 years (last supplementation in year 49). The carrying capacity of this relatively small Kanha meadow was assumed to be an unchanging 200 animals.

Scenario 3: This scenario envisages a situation similar to the first but with the supplementation being a single female and two males every 7 years.

Table 11: Result of harvest from the source population to supplement an introduced population in Kanha Tiger Reserve.

Attributes	1	2	3	4	5	6
Growth rate r (SD)	-0.1 (0.059)	-0.095 (0.059)	-0.1 (0.059)	-0.092 (0.059)	-0.102 (0.058)	-0.096 (0.06)
Probability of Extinction	0.9%	1	0.990	1	0.998	0.996
Expected heterogeneity	30.56	0	53.14	0	55.47	43.94
Time to extinction (median)	56	57	57	56	55	57
Carrying capacity (K)	500	500	366	366	366*	366*
Initial population	366	366	366	366	366	366
Final population	0	0	0	0	0	0

The six different scenarios are based on the following assumptions:

Scenario 1: The rate of growth is negative for this population of barasingha *Cervus duvauceli branderi* in Kanha Tiger Reserve. With harvest of five adult females and two adult males at an interval of 2 years from this population, it is likely to go extinct in about 56 years (see Table 11).

Scenario 2: The harvest being 4 adult females and 1 adult male to supplement the introduced population, this population is likely to go extinct by 57 years as it already has a negative growth rate.

Scenario 3: If the carrying capacity is assumed to be 366 and the rate of harvest as in scenario 1, the population is predicted to be extinct by 57 years.

Scenario 4: With a carrying capacity of 366 and rate of harvest similar to that of the second scenario, the population is likely to be extinct by 56 years.

Scenario 5: With the carrying capacity decreasing at a rate of 2% per year for a period of 10 years, a negative growth rate, and the rate of harvest as in the first scenario, the population is predicted to go extinct by 55 years.

Scenario 6: With a declining carrying capacity (as in scenario 5), a negative growth rate, and the rate of harvest as in the second scenario, the population is likely to go extinct by 57 years.

Table 12. Results of further harvesting of barasingha from a population with negative growth rate to supplement an introduced population.

	r (SD)	P(E)	HET	TE	K	IP	FP
Carrying capacity (K) = 500 animals. See text for details							
Scenario 1A	-0.19 (0.196)	1	0	43	500	203	0
Scenario IB	-0.234 (0.251)	1	0	42	500	203	0
Scenario 2A	-0.2 (0.225)	1	0	43	500	202	0
Scenario 2B	-0.225 (0.261)	1	0	43	500	202	0
Carrying capacity (K) = 366 animals. See text for details							
Scenario 3 A	-0.194 (0.2370	1	0	43	366	201	0
Scenario 3B	-0.246 (0.294)	0.99	61.11	42	366	201	3
Scenario 4A	-0.186 (0.2080	1	0	43	366	205	0
Scenario 4B	-0.233 (0.264)	1	0	43	366	205	0
Carrying capacity (K) = 366 and decreasing by *2%* per year for 10 years							
Scenario 5A	-0.191 (0.203)	1	0	43	366*	197	0
Scenario 5B	-0.23 (0.268)	1	0	42	366*	197	0
Scenario 6A	-0.18 (0.206)	1	0	43	366*	203	0
Scenario 6B	-0.235 (0.25)	1	0	43	366*	203	0

The simulations of the harvesting begins after the population has been harvested initially for the establishment of the new population in Kanha Tiger Reserve.

This initial harvesting was assumed to have taken from the population:

a. Two adult males and five adult females every two years for a period of five years. (Scenarios 1,3, and 5)

b. One adult male and four adult females as above. (Scenario 2,4, and 6)

This population is further harvested every seven years to supplement the introduced population in Kanha with the following sex ratios:

i. One adult male and one adult female extracted from the population every seven years for 50 years (Scenario A).

ii. Two adult males and one adult female extracted from the population every seven years for 50 years (Scenario B).

The final set of simulations was carried out with a decreasing carrying capacity in order to reflect the encroachment of woody species in the grassland.

Implications Of the Simulations

Effects of supplementation of the new population.

Assuming that the new area can support a carrying capacity of 200 animals, the simulated populations show healthy signs of growth. Varying the sex ratio of the new introductions produced little effect on population numbers. In all cases, the population of deer rose to carrying capacity and fluctuated around it (see Table 10). There is no appreciable decrease in the levels of heterozygosity if an additional male is added to the population with each supplementation. These models of course, assume that the population size is not density dependent and that the population is well managed against disease and poaching. No natural disasters were built into the model as well, to keep the interpretation simple.

Effects of harvesting on the main meadow population.

The Kanha population shows a negative growth rate and removal of animals from such a population is risky if not unwise. The population, given the current growth rate of the stock would, by our simulations go extinct within 55 to 57 years given the rates of harvesting suggested by the workshop participants for the initial introductions. However, the declining trend in the population (negative growth rate was calculated from the existing census figures from 1989 to 1994) is not affected more due to the harvesting. Carrying capacity does not have any effect on this extinction rate and even with a carrying capacity that decreases at a rate of 2% over the next ten years, there is no change in the time to extinction.

The subsequent, more sustained harvesting of this population over a fifty year time period proves even more detrimental to the population. Here, regardless of varying sex ratios and varying numbers of animals extracted, the populations all plummet to extinction within 42 to 43 years.

Suggestions for Management

1. The proposed new population in Kanha shows promise in the models and should be considered actively as a step towards maintaining a buffer stock of animals.

2. This population should be carefully guarded against poaching. They should also be constantly monitored for signs of disease.

3. Since inbreeding does not seem to be a problem, so long as the initially introduced individuals are not inbred, it makes little difference whether one male or two males are added.

4. Since the population is eventually going to grow to and be limited by carrying capacity very quickly (the population rises to 196 animals in 25 years), it may not be necessary to continue the supplementation for as long as proposed. Supplementations up to the 21 st year may suffice to allow the population to grow to carrying capacity.

5. Harvesting the Kanha meadow population in order to supplement the new population appears to be an extremely unwise decision in the light of the fact that this population already shows a negative growth rate. Any harvesting of a declining population will result in accelerating the rate of decline and lead to extermination of that population in less than fifty years. However, if the present conditions continue the population is at high probability of extinction during the same time frame.

6. It is proposed that a captive stock of this *C. d. branderi* be established as soon as possible, though it may have to be built upon a small parental/base stock.

7. Further management of the main Kanha meadow needs to be implemented in order to check the declining population. Measures need to be taken to prevent the loss of the already limited habitat either due to encroachment by woody species or grazing pressure.

Summary and Recommendations

We have examined the effect of several factors (e.g., poaching, predation, % males breeding, carrying capacity) on barasingha populations in general, as well as very specific questions relating to specific populations (e.g., Sathiana). The initial model presented here should be considered only a first step in developing a more complete model for barasingha populations as additional data become available. To further develop the model for the purpose of gaining a better understanding of barasingha population viability, we recommend that:

1) Annual census estimates are needed for all populations. The census should record as accurately as possible the age structure of each population.

2) Basic life-table data on age and sex specific mortality and fecundity rates need to be collected for barasingha. In particular, accurate estimates of neonatal and adult female mortality, and fawn production (with confidence intervals) are needed. This requires the initiation of long-term field studies involving radio collaring animals that focus on the population biology aspects of barasingha biology. Ideally, the study should be done in more than one, and preferably 3 or 4 populations in different types of habitats to estimate the variance in demographic effects due to habitat and environmental variation.

3) The models indicate an extreme sensitivity to the amount of poaching and predation pressures on the populations. In particular poaching rates need to be monitored continuously in these populations.

4) Estimates of population size limits (the "carrying capacity" values needed for the VORTEX model) for each population are also needed. In addition, expected changes in the carrying capacity need to be estimated. Changes due to management actions, as well naturally occurring factors should both be estimated.The effective population size of barasingha is sensitive to the % of males in the breeding pool. Current estimates vary between 100% and 12%. To better estimate the effective population size, the percent of males actually participating in breeding needs to be know. Variance in male reproductive success is particularly important.

5) In the Dudhwa metapopulation, studies should be continued to monitor migration rates among the populations and the likelihood of migrating and dispersing animals actually reproducing.

Section III. Habitat, Census, Distribution and Threats

III. HABITAT, CENSUS, DISTRIBUTION AND THREATS

(Facilitator: S. C. Sharm; Ashwini Pai, Recorder; Members: Ravi Chellam, R. S. Chundawat, Y.V. Jhala, Moh'd Khalid, S. B. Lowlekar, S. N. Prasad, Qamar Qureshi, A. K. Raha, Rajeshree Sharma, V. P. Singh, S. P. Sinha,D. N. S. Suman, Diwakar Sharma,K. Shankar,Ravi Shankar,Rakesh Shukla, Rakesh Tomar.)

The working group focused on the following issues:

1) What are the populations to be considered?

2) What are the present census figures for each of these populations?

3) What is the estimated carrying capacity for each of these populations for the areas that they are located in?

4) The major catastrophes and their effect on the population i.e. the mortality caused by these catastrophes

5) The major threats and the mortality caused by these threats

6) Feasible management plans and strategies to maintain a stable/viable population in the present areas of distribution.

Estimates and figures were arrived at after consulting secondary literature and notes from the field managers and biologists.

The Populations

The distinct populations or "Demes" that were identified by virtue of their geographic locations are as follows:

Uttar Pradesh

1) Sathiana
2) Kakraha
3) Bankithal
4) Bhadhiand Nagraha
5) Kishanpur Wildlife Sanctuary
6) Katerniaghat
7) North Pilibhit Forest Division
8) Hastinapur

Nepal

9) Sukhlaphanta
10) Kamali Bardia

** All the above populations except the one at Hastinapur lie in Dudhwa or in its vicinity.*

Madhya Pradesh

11) Kanha

Assam

12) Manas
13) Kaziranga

Population Estimates

The present population estimates were arrived at after consulting the census figures available with the forest department and the biologists.

Census estimates in all areas are made by the Total Count method. The time of the year varies from protected area to protected area and is dependent on the factors of visibility and time of aggregation of the barasingha populations (immediately after rutting).

For Dudhwa census of the barasingha is carried out in January - February, after the burning of grass and when the barasingha population starts aggregating. In Kanha, the census is carried out in the first week of July for three successive days when practically all the barasingha have aggregated on the meadows for grazing. An improvement on this method can be to count the barasingha twice - during the peak of the rutting season and again after the peak of the rutting season. Ideally, the barasingha should be counted 4 or 5 times in the suitable season to get statistically reliable estimates. Where total counts are not possible, transects (using elephants) can be laid to get population estimates.

Management carrying capacity has been estimated as the maximum number of animals recorded in the area in its history or the best possible number that the area could support, based on the intuition of the field managers and researchers from these areas.

Mortality:

Factors contributing to mortality every year were floods in the populations in Uttar Pradesh (except for Hastinapur) and predation in all the populations. Flooding affects only the fawns and not the adults of the populations.

The major threat that contributed to decrease in the population was poaching. Average poaching detected from 1978 to 1989 is about fifty per year. Out of these cases about one fifth are barasingha i.e. 10 cases per year. It is estimated that the unrecorded poaching is 2.5 times the recorded poaching cases. Hence the number of barasingha killed by poaching is 35 every year. If the overall population of Dudhwa National Park is 700, then the overall mortality due to poaching is 5%.

Table 13: Census estimates and carrying capacity figures of the various populations of the barasingha.

NAME OF POPULATION	PRESENT POPULATION ESTIMATES	MANAGEMENT CAPACITY
Sathiana, UP	125	400
Kakraha, UP	500	700
Bankithal, UP	125	200
Bhadhi&Nagraha,UP	100	200
Kishanpur, UP	400	600
Katernighat, UP	50	1000
Pilibhit, UP	200	400
Hastinapur, UP	25	50
Sukhlaphanta, Indo-Nepal Br	1750	1000
Karnali Bardia, Indo-Nepal Br	50	100
Kanha,MP	366	2000
Manas, Assam	50	100
Kaziranga, Assam	427	800

Table 14: Factors contributing to mortality and their estimates (in per cent).

Name of population	Poaching	Flood	Predation
Sathiana, UP	5%	20% (fawn)	5%
Kakraha,UP	2%	l%(fawn)	5%
Bankithal, UP	2%	l%(fawn)	*5%*
Bhadhi&Nagraha,UP	2%	l%(fawn)	*2%*
Kishanpur, UP	2%	l%(fawn)	5%
Kateraighat, UP	2%	l%(fawn)	2%
Pilibhit,UP	2%	l%(fawn)	*2%*
Hastinapur, UP	2%	l%(fawn)	-
Sukhlaphanta, Indo-Nepal Br	2%	l%(fawn)	*2%*
Karnali Bardia, Indo-Nepal BR	2%	l%(fawn)	*2%*
Kanha,MP	0	0	*2%*
Manas, Assam	Not known	nk	nk
Kaziranga, Assam	nk	nk	nk

Catastrophe:

Since there are no data for any catastrophe to the barasingha populations except Kaziranga, the group decided to consider a disease that would wipe out half the numbers of the present populations (i.e. mortality caused by catastrophe would be 50% of the population). The Kaziranga population sharply declined in the 1990s in part as a result of severe floods in the 1990s. The census figures for Kaziranga have been recorded in Table 15.

Table 15: Population Figures for Kaziranga

YEAR	1966	1972	1978	1984	1991	1993
CENSUS	213	516	697	756	635	427

Table 16: Recruitment Figures for Various Classes of Barasingha (source Q.Qureshi)

Area	Males: 100 Females	Fawns: 100 Females
Satiana	54.8	44.30
Kakraha	54.8	44.30
Bankital	54.8	44.30
Bhadhi&Nagraha	54.8	44.30
Kishanpur	54.8	44.30
Katernighat	54.8	44.30
Pilibhit	54.8	44.30
Suklaphanta	45.71	46
Kamali Bardia	45.71	46
Hastinapur	-	
Kanha	59.45	36.29
Manas	-	-
Kaziranga	47.05	30

Management Suggestions and Strategies

Management problems and feasible strategies for each of the populations was discussed. A general agreement on necessary action for the populations was arrived at

Uttar Pradesh

Sathiana population (Dudhwa National Park) has its breeding grounds outside the National park on private land (in Goia and Gajrola). The Sathiana population uses these breeding grounds for about five to six months (June-January) every year. These breeding grounds cannot be physically duplicated inside the park. Land acquisition is near impossible as the area has been politically over sensitized. Habitat manipulation for the barasingha in Sathiana must not eclipse the management issues dogging other endangered species in the area (viz. the Bengal Florican and the Hispid Hare) or other native species.

Management measures suggested for this population are as follows

Creation of "chowkis" (patrol areas) during the crucial 5-6 months so as to mitigate the problem of poaching. The added patrolling will give only a better . chance for the survival of the population and will not be a solution to all the threats to the population.

The population at Sathiana needs to be closely monitored for variation in population numbers. Relocation of the population would have to be taken up only as a last resort and only after gathering the opinions of both field managers and research biologists. Relocation should be to other areas within Dudhwaonly.

There is the need to renovate the road connecting Bumnagar Chauraha, Sumer Nagar, Kema Gowdi and Gauri Phanta.

Other populations in Pilibhit and Katerniaghat need to be built up by providing added protection.

The opening of the Soheli Barrage floodgates has to be in conjecture with the Forest department.

Kishanpur Wildlife Sanctuary has a severe constraint of staff. The management also wants to provide water to the wildlife in summer without disturbing the water regime of the area. The management suggestions made were as follows.

Staff and infrastructure at Kishanpur Wildlife sanctuary need to be built up.

There must be monitoring of the Jhadithal and Ull river areas as the barasingha population is distributed along these.

The plantations of Eucalyptus and teak have to be removed.

To not disturb the water regime of the area, which is of crucial importance to barasingha, it is suggested that water be pumped in during the summers.

North Pilibhit population needs the following management.

The entire Terai tract, being a unique ecosystem, needs to be brought under the unified command of wildlife wing.

Plantations along the entire Terai tracts must be discouraged.

A study of the Pilibhit populations - its movement, rutting, etc. need to be carried out.

No human settlements must be allowed near Lakkabagha to ensure further protection.

There must be a control on grazing.

Wildlife extension activities must be carried out near all barasingha areas.

Efficient fire management, augmented by studies are essential.

Katerniaghat population

Remaining barasingha population should be monitored and site prepared for future translocations from other areas.

The state seed farm in Baharaich Distt. should be closed and infrastructure removed.

Hastinapur population

This population needs to be studied and protected more extensively before any concrete management steps can be recommended.

Madhya Pradesh

Kanha Population

The enclosure that had been made for studying the barasingha population on the advice of IUCN must be put to use again. Barasingha should be driven into the enclosure and allowed to proliferate and their breeding patterns must be studied.

Efficient management of controlled burning of meadows is needed. Burning must be completed by January.

Barasingha from Kanha and Mukhti must be relocated to the meadows of Supkhar. A sanction for this already exists.

There must be a monitoring of the meadows and encroachment of meadows by woodlands must be looked into. Rate of invasion has to be studied.

The barasingha population must be monitored regularly for diseases.

There must be proper ecological monitoring of barasingha population in Kanha.

It is suspected that jackals are preying on the young of the barasingha in Kanha causing mortality of the fawns. Studies to confirm the same are necessary.

***Assam* (Kaziranga and Manas)**

Patrolling must be intensified especially along the northern and the southern areas during the floods.

There must be better infrastructure and incentives for the staff.

Encroachments on the western side and the land use structure must be defined.

There must be detailed studies of the population in Kaziranga.

There must be a monitoring of the movement patterns of barasingha popula tions in both the protected areas, especially during floods.

Population trends, threats, and protection measures need closer investigation

Manas has to have status survey of the population as no figures are available from the protected areas after insurgency in the area. Additional patrolling must be done.

Section IV. Translocation and Reintroduction

IV. TRANSLOCATION AND REINTRODUCTION

Facilitator: Vinod Rishi; Recorder: S. Saunand; Members :Pushp Kumar, Ashok Singh, M. C. Ghildial, Mohd. Ahsan, A. K. Raha, H. S. Pabla, S. P. Sinha

Before identifying the actions to be taken, the group identified the following as key questions:

1. Is there a need to conserve the barasingha population in the barasingha range states in India?

2. If so, whether there is a need for reintroduction or translocation of barasingha?

3. Is there any possibility of doing so in terms of:

    a. Stock availability - status
    b. Habitat availability - status (feasibility indicators)
    c. Knowledge of technique - availability and qualitative status, identification of the target sub-species.

4. Selection of habitat focus area(s)

5. What is the strategy proposed?

6. Implementation guideline(s)

Uttar Pradesh *(Cervus duvauceli duvauceli)*

Historical record: It was present in Terai in thousands in 1940's as past records show.

Need for conserving the species: The following are the major points justifying management intervention

1. Status is dwindling - there is a need for recovery,

2. High level of threats to populations and habitats,

3. Need to safeguard against catastrophe,

4. Need for genetic exchange or gene flow among the fragmented populations,

    a. For Katemighat Wildlife Sanctuary - reinforcement of the existing population by translocation from one or more of the five areas having non-viable populations, e.g. Faizabad Division, in a phased manner in accordance with an approved Action Plan on an experimental basis.

b. For Suhagibarua Wildlife Sanctuary: The area should be intensively surveyed to evaluate its suitability. The intervention suggested is that of reintroduction. The stock may come from free-ranging as well as the captive bred stock. At present there is no population of barasingha in this former habitat of the species.

c. Only standard management practices are needed for strengthening the habitat of Pilibhit Division.

The priority for action has been recommended for option (a) above. The IUCN guidelines for reintroductions will be taken into consideration.

Madhya Pradesh *(Cervus duvauceli branded)*

Need:

1. Single large population and status does not indicate an increasing trend in existing population.

2. To safeguard against any catastrophe

3. To create a second home for the present population

Need identification:

Criteria accepted for recognizing the need for management intervention for conservation of barasingha in MP include:

1. Intervention is justified as the status of this unit of population has been showing a declining trend in the recent past

Intervention is also necessary as no second population is known to exist either in wild or any of the zoos, a fact which calls for a greater concern for augmenting genetic variability as well as safeguarding the species against any catastrophe.

Intervention is also considered necessary as the meadows, which are very necessary for grazing, mating, breeding, fawning and rearing activities of barasingha are being invaded by fast-spreading woody species having an adverse effect on barasingha

2. Indicators of feasibility of intervention. Options:

a) Reinforcement is ruled out due to lack of resource stock in India outside Kanha National Park.

b) Reintroduction may be considered in Achanakmar Wildlife Sanctuary or Bandhavgarh National Park from resource stock taken from Kanha.

Translocation of the stock from Kanha to Achanakmar is more feasible than to Bandhavgarh in terms of the distance and habitat suitability.

3. Strategy

a) Study of habitat ecology and species biology

b) Plan for 20 years - 4 phases of 5 years duration each

c) Translocation in a phased manner Adults from Kanha NP

I)	1st year	2:5 = 7
h)	2nd year	2:5 = 7
in)	5th year	1:4 = 5

Review every five years for future intervention if required.

d) Reintroduction program will be implemented in accordance with an approved Action Plan. The IUCN Guidelines will be taken into consideration.

West Bengal

Need identification:

1. West Bengal has been until recent times (31-35 years ago) a barasingha range state.

2. The need for rehabilitation of a sub-population of barasingha in a viable habitat in North Bengal is strongly felt to provide an important link for reestablishment of the contiguity of the historical range of *Cervus duvauceli ranjitsinhi*.

3. Areas considered were the terai cum riverine grassland of N. Bengal viz. flood plains of Tista, Murti, Torsa, and Raidak. The most likely candidate for the reintroduction is the riverine grassland habitat of torsa flowing through Jaldapara WLS where the existence of barasingha was known.

4. Jaldapara topographical configuration and problems for protection arising out of is a management limitation, but considering various pros and cons experimental reintroduction of barasingha in the overall interest of the conservation of the species can be considered.

5. The source of barasingha for reintroduction will be explored from captive bred stock of *Cervus d. duvauceli* or if available, free ranging stock of *Cervus d. ranjitsinhi* from Assam to strengthen the conservation status of the *Cervus d. ranjitsinhi.*

This needs further feasibility examination

6. The IUCN Guidelines for reintroduction will be kept in view while finalizing a strategy for the final action. At this stage the information available was insufficient to help develop a strategy for consideration for the translocation and reintroduction of barasingha stock into Jaldapara WLS.

Assam *(Cervus duvauceli ranjitsinhi)*

Needs identification:

1. There is at present only one large single surviving group or unit of this subspecies in Assam.

2. Recent decline in satellite habitats; so to reinforce a satellite

habitat

3. Safeguard against catastrophe.

4. No *ex situ* population exists.

5. A viable stock with sex ratio of # 2.5 should be introduced to the Assam State Zoo with immediate effect to support the conservation effort

Thus, in all the former habitats or historical range states (UP, MP, Assam and West Bengal) need is recognized for translocation or reintroduction of barasingha population.

REPORT on the P.H.V.A. for Barasingha

Section V. Captive Population and Captive Modelling Working Group

Management
Modelling

V. CAPTIVE POPULATION

Members: Pushp Kumar, Anil Kumar Dutt, J. H. Desai, A. K. Roychoudhury, P. Shankarnarayanan, and A. K. Bannerjee.

Introduction

In view of the threats to the barasingha population in the wild, it is strongly felt that *ex situ* conservation efforts in general need to be strengthened and towards this end it is felt necessary to improve and enhance the efforts to maintain stocks in zoos as standby for future conservation of the barasingha in the wild.

The position of the present stock in zoos and its better deployment was considered by the group.

1. Barasingha in zoos

1.1 At present ten zoos in India are maintaining barasingha.

1.2 The total stock in these ten zoos is 74, i.e., 25.34.15

1.3 LucknowZoo has the maximum stock of 41, i.e., 10.22.9

1.4 Out of ten zoos, five zoos have non-viable stock with adverse sex ratio. A statement of the present position is enclosed (Table 17).

2. Homogeneity in the captive stock

2.1 It is believed that all the captive stock in India has originated from one pair from Lucknow except for the stock at Bijnor (2 wild-caught males). Even the origin of animals at Darbhanga and Courtallam needs to be ascertained.

2.2 DN A fingerprinting of 20 animals of Lucknow stock is being done at C.C.M.B., Hyderabad. Report is awaited.

2.3 It is desirable that DNA fingerprinting of the animals at Indira Gandhi Deer Park at Bijnore, Bajarang Zoo, at Darbhanga and Courtallam Zoo, be carried out to ascertain the genetic differences of the animals in the above zoos.

2.4 It is desirable that new blood be infused from the wild or from any other source into the zoo stocks. Even by adding one pair from the wild every year to the present captive population, the heterozygosity can be maintained at a level of more than 80%.

3. **Relocation of Stock in** Zoos

3.1 It is recommended that viable barasingha captive population, all belonging to *Cervus duvauceli duvauceli*, should be maintained only at such places where good housing and breeding facilities exist.

3.2 It is recommended that one more zoo (i.e., the Patna Zoo) should be involved in the breeding program.

3.3 It is recommended that all the Bajrang Zoo, Darbhanga, stock of 0.0.2 should go to Patna. Courtallam stock of 0.0.1 should go to Mysore Zoo where there is already a small herd. One female from Bijnor should be sent to Kanpur Zoo. The animal of Bareilly Zoo and two males from Bijnor Zoo should be transferred to Lucknow Zoo. Two females from Lucknow Zoo should go to Kanpur Zoo, and one male and one female from Lucknow Zoo should go to Chandigarh Zoo and 3 males and 7 females from Lucknow Zoo should be maintained separately as a national herd preferably at Kukrail near Lucknow for future possible reintroduction.

3.4 To infuse fresh diversity from unrelated males from the wild one animal each can be introduced into Kukrail reserve and Lucknow, Kanpur, and Delhi zoos.

4. Maintenance of Records

4.1 All the animals should be marked with permanent identification number. For each individual animal, proper records of breeding biology, natality and mortality, and studbooks should be maintained by all institutions holding barasingha. These should be in formats approved by the Central Zoo Authority.

4.2 Relevant data for VORTEX modelling may be collected from the zoo population.

5. **Species Coordination**

5.1 Species coordination should be done by interchanging zoo stocks from one center to another in accordance with a carefully planned program and care should be taken to avoid mortality in capture and transport.

5.2 In species coordination it is necessary to take into account the taxonomic difference and purity of subspecies.

6. Conservation of Hard Ground Barasingha *(Cervus duvauceli branderi)*

It is recommended that viable groups of hard ground barasingha should be distributed from Kanha paddock to the following zoos:

VanVihar,Bhopal,MP	2.5
Nehru Zoological Park, Hyderabad	2.5
Nandankanan Biological Park, Orissa	2.5

7. Conservation of Eastern Population *(Cervus duvauceli ranjitsinhi)*

It is also recommended that 2 males and 5 females out of about 500 existing wild stock of eastern population should be maintained at Guwahati Zoo.

8. Captive Management

The species is easy to maintain in captivity and does not require any special attention or care. It is recommended that housing, upkeep and veterinary care should be according to the zoo rules of the Central Zoo Authority.

9. Import of Animals

Since the origin of founders of captive population in Europe and America is not clearly known the possibilities of hybridization of northern and northeastern subspecies of Swamp deer cannot be ruled out. Therefore, it is not appropriate to use foreign stocks for reintroduction of captive population in India.

10. *Ex situ* Conservation Outside India

The main priority of the Swamp deer conservation program concentrates on strengthening and protecting the *in situ* as well as *ex situ* populations in India. It would not be desirable to export any Swamp deer for *ex situ* program outside India at this time.

11. Zoo Education

In zoos where barasingha and other endangered animals are being maintained, the conservation need of these species should be highlighted. Zoo visitors should be appraised of special efforts being taken to protect the species.

The zoo keepers should also be effectively educated and trained about the management and upkeep requirements of the species.

Table 1. Barasingha *(Cervus d. duvauceli)* distribution in Indian zoos before and after relocations).

State	Zoological Park		M	F	Unk	Total
Bihar						
1.	Bajrang Zoo, Durbhanga	(a)	0	0	2	2
		(b)	0	0	0	0
2.	Sanjay Gandhi Zoo, Patna	(a)	0	0	0	0
		(b)	0	0	2	2
New Delhi						
3.	National Zoo, Delhi	(a)	3	6	0	9
		(b)	4	6	0	10
Karnataka						
4.	Mysore Zoo, Mysore	(a)	2	2	2	6
		(b)	2	2	3	7
Punjab						
5.	Chhatbir Zoo, Chandigarh	(a)	1	2	0	3
		(b)	2	3	0	5
Tamil Nadu						
6.	Mini Zoo, Courtalam	(a)	0	0	1	1
		(b)	0	0	0	0
Uttar Pradesh						
7.	Indira Park, Bijnor	(a)	2	1	0	3
		(b)	0	0	0	0
8.	Kanpur Zoo, Kanpur	(a)	6	1	0	7
		(b)	7	4	0	11
9.	Lucknow Zoo, Lucknow	(a)	10	22	9	41
		(b)	9	12	10	31
10.	IVRI, Bareily	(a)	0	0	1	1
		(b)	0	0	0	0
11.	Indira Manoranj an Van	(a)	1	0	0	1
	Lakhimpur-Kheri	(b)	1	0	0	0
12.	Proposed herd at Kukrail	(a)	0	0	0	0
	Total 12 Zoos:	(b)	4	4	0	11
			25	34	15	74

(a) = Number before relocations, (b) = Number after relocations.

CAPTIVE POPULATION MODELLING

Members: P. Shankaranarayanan, M. Khalidand Sanjay Molur

The group modelled scenarios as applicable to the captive populations existing in the zoos in India. The captive management group felt the need to find options for managing the captive populations genetically and demographically in the zoos.

The present population of barasingha in captivity have arisen from a founder stock of 2 males and 1 female. In 20 years, the numbers increased to 74 as of today.

The models were tested from 20 years ago for mean population size existing today to see the levels of heterozygosity retained in the population. On this basis supplementation was modelled to see the effect on the heterozygosity of the population. The main objective of this group was to model various options and suggest optimum management scenarios in captivity so as to help the population retain maximum genetic diversity.

All the scenarios were modelled with inputs provided by the captive management groups

Basic Scenarios

Initial population and carrying capacity: Models were tried with different initial population sizes of 3,10 and 74 individuals. The carrying capacity was fixed at 100 for all of these scenarios.

Age at first reproduction: The age at first reproduction for females was entered as 3 and for males as 5 years.

Fertility rates: Ninety percent of the females were assumed to breed every year. This figure varies from that of the wild because of better living conditions in the zoos. All males were assumed to have an equal opportunity to breed.

Mortality rates: Three different neonatal mortality rates were modelled, viz. 5,10 and 15 percent (SD l/3rd). Sub adult mortality was modelled at 3% (SD 1) and adult mortality at 1.5% (SD .5). This was same for both males and females.

Catastrophes: Catastrophes were not modelled.

Inbreeding depression: Models with inbreeding depression of 0,1 and 3.14 were tried.

Simulations were run for either 50 or 100 years and 100 iterations each.

Scenarios modelled:

A. 1:1 (Adults) were supplemented every year from the 21 st year to the 30th year.

At the start of the supplementation programme, the heterozygosity level was at 68% but with the additions heterozygosity levels went up to 82% at the end of the 30th year when additions were stopped and levelled off at 80% when observed on the 50th year.

B. 1:1 (Adults) were supplemented every year from the 21 st year to the 50th year.

The animals were added for 30 years, i.e., 60 animals. The heterozygosity increased from 68% to 81% by the 10th year of addition and 86% by the 30th year.

C. 1:1 (Adults) were supplemented once every 5 years from the 21 st year to the 50th year.

Animals were added at 5 year intervals. The heterozygosity increased from 68 % to 74% in the first 10 years and to 76% in 30 years.

D. 1:1 (Adults) were supplemented once every 3 years from the 21 st year to the 50th year.

The supplementation of animals at 3 year intervals increased the heterozygosity from 68 to 76% in the first ten years and to 79% in 30 years.

E. Higher sex ratio of 2:1 (adults) in supplementation was tried out. The supplementation was done once every 5 years from the 21st year to the 50th year.

Supplementation of animals at 5 year intervals with a higher sex ratio of 2:1 increased the heterozygosity from 68% to 76% in the first 10 years and to 80% in 30 years. There is no difference in the heterozygosity values if the sex ratio is changed

F. In this scenario, inbreeding depression was taken into account.

1.1.1 (adults) were supplemented once every 5 years. The inbreeding coefficient was taken as 1 lethal equivalent and mortality rates were 5,10,15%.

The supplementation was done every 5 years. The increase was from 69.3 to 75% in the first 10 years and to 78% in 30 years.

2. 1.1 (adults) were supplemented once every three years. Inbreeding coefficient was taken as 1 lethal equivalent and mortality was 5, 10,15%.

Supplementation was done every 3 years and the change in heterozygosity was from 69.3 to 78% in the first 10 years and 82% in 30 years. There was a marginal increase in heterozygosity retained between the three year and five year intervals.

3.2:1 (adults) were supplemented once every 5 years. LE = 1 and mortality rate 5,10,15%

F3 Supplementation was done with animals having a higher sex ratio of 2:1 every five years. The increase was from 69% to 78% in the first ten years and to 82% in 30 years.

Higher sex ratio used once in five years seemed to produce the same effect as supplementation of 1.1 once in three years.

G. 5:5 (adults) of wild origin were supplemented with 10 animals of the captive population with LE = 3.14.

H. 6:4 (adults) of wild origin were supplemented with 10 animals of captive population with LE = 3.14.

I. 1:1 (adults) were introduced into the population from the 21st to the 30th year after all but 5 adult males and 5 adult females were harvested. This was to ensure that the captive population at that year had retained as much heterozygosity as at present. Heterozygosity retained by the 20th year was 69% when the population was supplemented by the first pair. By the 30th year when supplementation was stopped, heterozygosity had increased to 87%.

File Name	% Mortality	H at 30 years	H at 50 years
1:1 adults added every year from years 21 to 30, LE = 0			
n3m35m1f1	5	81.2	79.2
n3m10mf	10	82.6	80.8
n35mf1	15	83.1	81.4
1:1 adults added every year for 30 years from years 21 to 30, LE = 0			
n3m5m1f150	5	80.7	86.4
n3m10mf50	10	81.9	86.9
n35mf150	15	81.1	86.9
1:1 adults added every 5 years from years 21 to 50, LE = 0			
n3m5m1f15	5	72.8	76.2
n3m10mf5	10	74.1	76.9
n35mf15	15	74.3	77.4
1:1 adults added every 5 years from years 21 to 50, LE = 0			
n3m5m1f15	5	74.5	77.5
n3m10mf5	10	74.0	77.2
n35mf15	15	75.7	79.0

1:1 adults added every 3 years from years 21 to 50, LE = 0			
n3m5m1f13	5	77.5	81.8
n3m10mf3	10	77.9	81.4
n35mf13	15	78.1	82.5
1:1 adults added every 3 years from years 21 to 50, LE = 1			
n3m5m1f15	5	77.5	81.8
n3m10mf5	10	77.9	81.4
n35mf15	15	78.1	82.5
2:1 adults added every 3 years from years 21 to 50, LE = 0			
n3m5m1f1	5	75.2	79.6
n3m10mf	10	76.6	81.3
n35mf1	15	76.1	80.2
1:1 adults added every 5 years from years 21 to 50, LE = 0			
n315mi1fh	5	77.7	82.1
n310ifh	10	78.0	82.8
n3m5i1gh	15	78.0	82.3

File Name	% Mortality at 0-1 age	H at 10 years	H at 20 years	H at 50 years
5:5 adults added initially to 10 animals in captivity, LE = 3.14				
n10m5s10	5	96.4	95.1	91.4
n 3m10mf	10	96.5	95.2	91.3
n35mf1	15	96.5	95.3	91.5
6:4 adults added initially to 10 animals in captivity, LE = 3.14				
n10m5s64	5	96.5	95.2	91.1
n 3m10mf	10	96.5	95.2	91.1
n35mf1	15	96.5	95.3	91.0
1:1 adults added to the harvested population for 10 years, LE = 1				
n10m5s2	5	69.2	87.4	86.3
n 10m10s2	10	69.3	88.0	87.0
n10s2	15	68.1	87.7	86.8

All the above scenarios suggest a steep increase in heterozygosity when animals from the wild are supplemented.

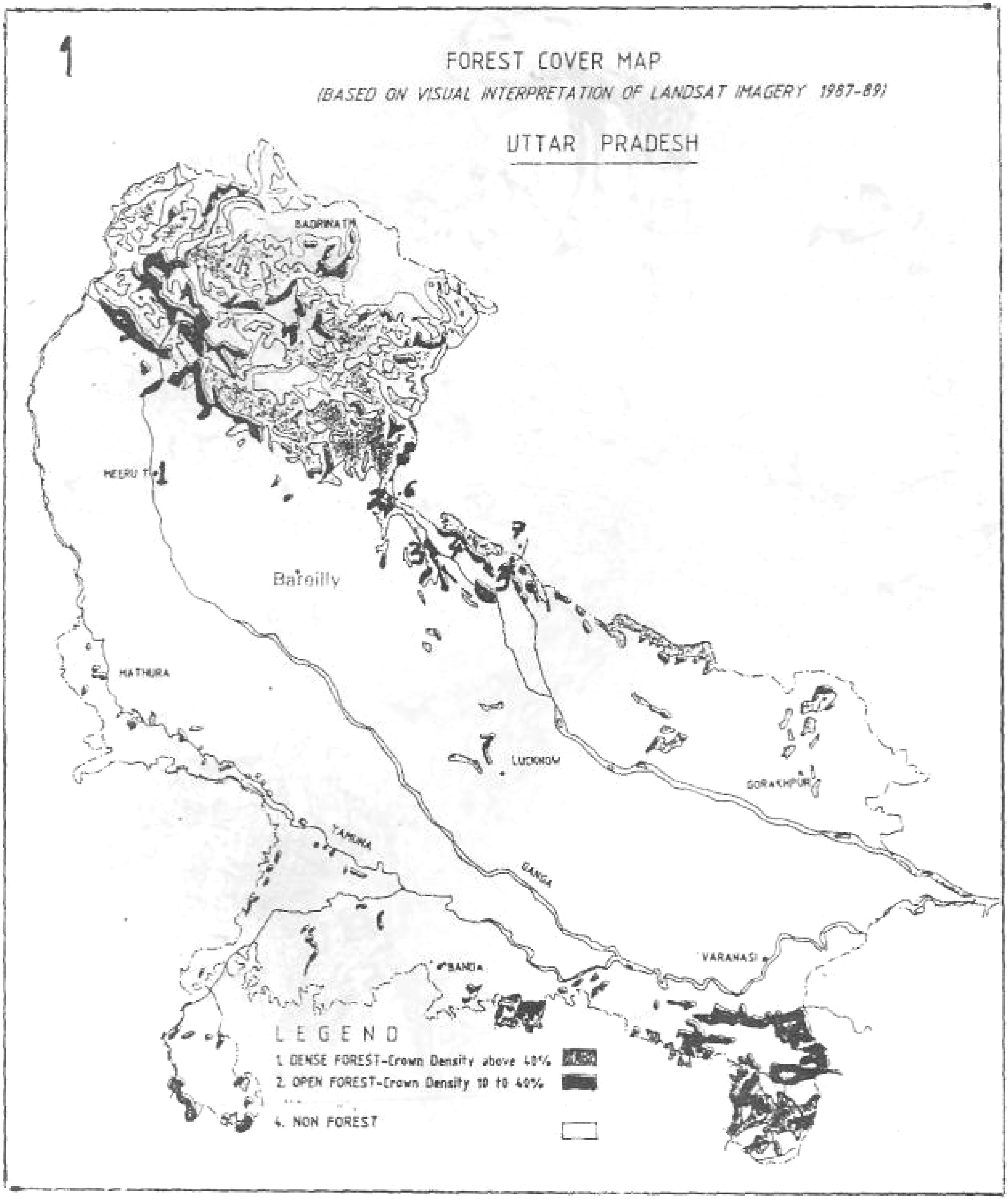
If the entire captive population is to be maintained as a breeding stock, supplementing 2:1 animals every five years for 30 years increases the amount of heterozygosity retained similar to supplementing a pair every year for 30 years. However, the population should be intensively managed.

If just 10 individuals from the captive population constitute the founder animals for a breeding programme, to increase their heterozygosity, a pair should be introduced every year for ten years. The model shows the population thus formed to have a diversity of 87% at the end of 50th year. However, this could be increased with intensive management.

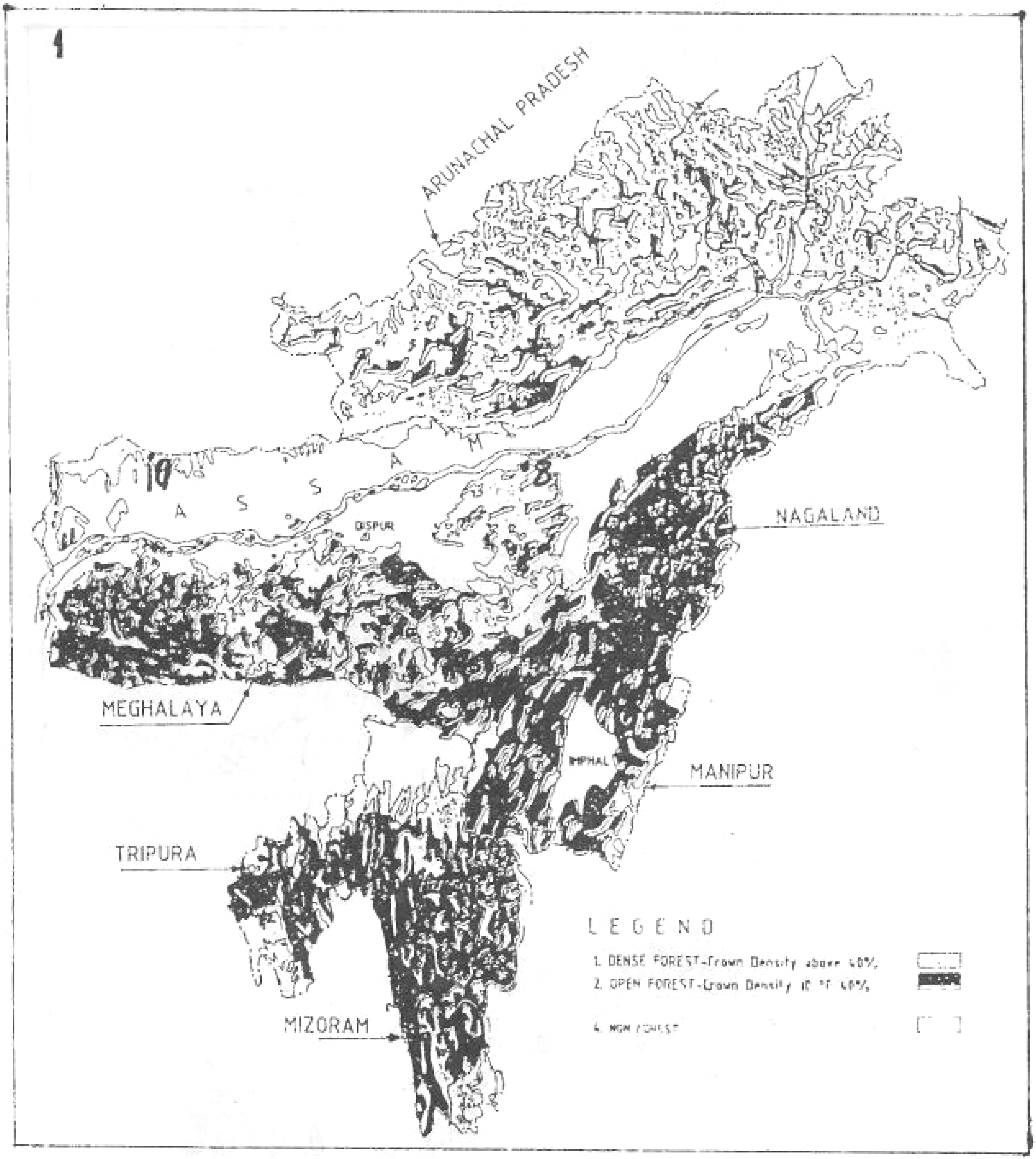
REPORT on the P.H.V.A. for Barasingha

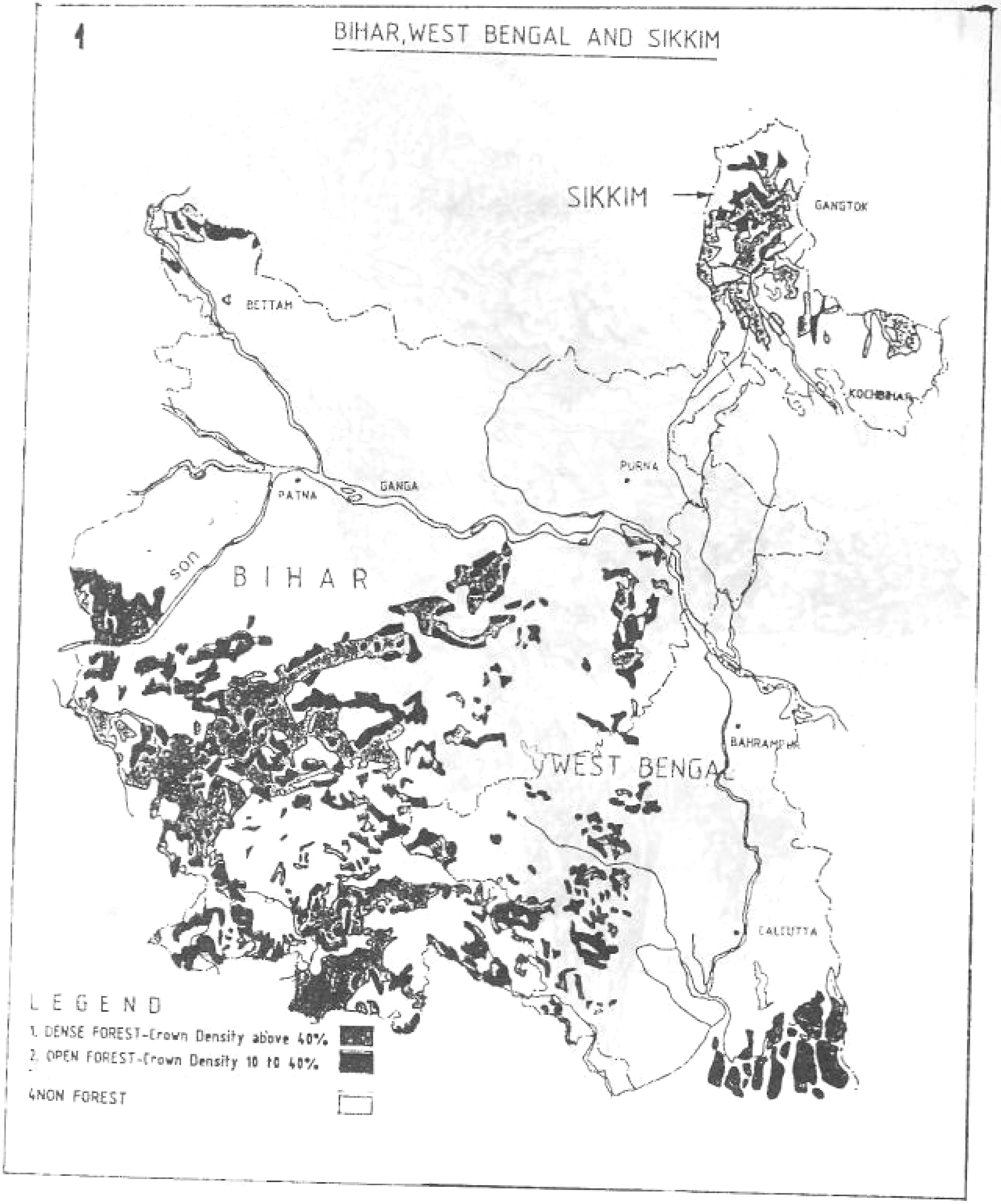
Section VI. Appendices

Maps
PHVA and VORTEX basic material
List of participants of Barasingha PHVA Correspondence (invitations)
Inaugural speech of S. C. Dey
Report on Training in Small Population Biology and the CBSG Processes

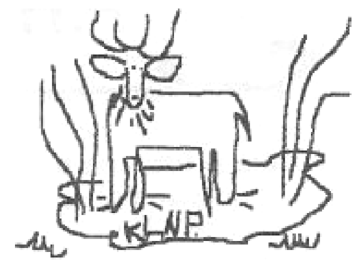

1
FOREST COVER MAP
(BASED ON VISUAL INTERPRETATION OF LANDSAT IMAGERY 1987-89)
UTTAR PRADESH
BADRINATH
MEERUT
Bareilly
MATHURA
LUCKNOW
GORAKHPUR
YAMUNA
GANGA
VARANASI
BANDA
LEGEND
1. DENSE FOREST-Crown Density above 40%
2. OPEN FOREST-Crown Density 10 to 40%
4. NON FOREST


1
MADHYA PRADFSH
Ujjain
BHOPAL
NARMADA
KHANDWA
SON
LEGEND
1.DENSE FOREST-Crown Density above 40%
2 OPEN FOREST-Crown Density 10 to 40%
4 NON FOREST

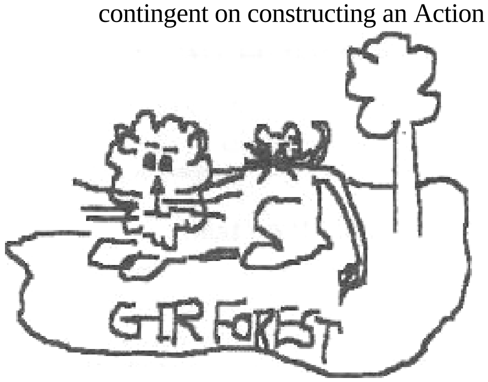

ARUNACHAL PRADESH
A S S A M
DISPUR
NAGALAND
MEGHALAYA
IMPHAL
MANIPUR
TRIPURA
MIZORAM
LEGEND
1. DENSE FOREST-Crown Density above 40%


1
BIHAR, WEST BENGAL AND SIKKIM
SIKKIM
GANGTOK
BETTAH
KOCHBIHAR
PURNA
PATNA
GANGA
son
B I H A R
BAHRAMPUR
WEST BENGAL
CALCUTTA
L E G E N D
1. DENSE FOREST-Crown Density above 40%
2. OPEN FOREST-Crown Density 10 to 40%
4NON FOREST

WHAT MAKES PHVA'S *DIFFERENT* **FROM OTHER WORKSHOPS** ?



Problem : You are down to the last small, population of a highly endangered species in a problematical area. Saving this species is completely contingent on constructing an Action Plan for Recovery that everyone will follow



Question : How do you do it ?
Answer: Construct the Action Plan *together* with all players agreeing to it ~ consensus.
Question : How do you do THAT ?
Answer: with FACILITATION SKILLS !
THAT'S what makes PHVA's different

Some VALUES of PHVA lie in their

* *bringing together all groups*
responsible for the saving species

* *building a consensus*
on actions needed for the recovery of species.

* *bringing together experts*
whose knowledge may assist rescue of species

* *providing an objective assessment*
of the risk of extinction of species

* *producing an objective report*
used as basis for policy & implementation actions

Some Principles of PHVA Workshops lie in

* *Fear of loss but hope for recovery*
of the taxon

* *Consensus among players*
on desired outcome

* *Potential Win - Win strategy*
when stakeholder interests and agendas differ

* *Complex problems*
with a *need* for diverse specialists

* *Need for an agreement*
to pool resources and willingness to do so . . .

**Outsiders acceptable*
(and needed) as resources and analysts.

HOW DO YOU MAKE DIFFERENT GROUPS & EXPERTS

AGREE!
&
MAKE

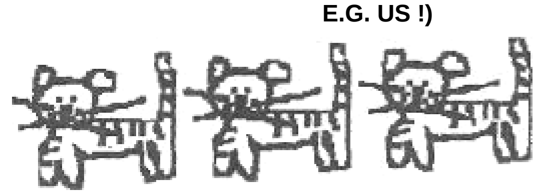
AN *OBJECTIVE* REPORT

BY CONSENSUS!

SO THAT EVERYBODY WILL

WIN-WIN

(ESPECIALLY THE SPECIES, E.G. US !)



P.H.V.A.GROUND RULES

1. Every idea, plan, or belief about the subject can be examined and discussed.
(This is to permit new ideas to surface, gives an opportunity to review aid ideas, and generally assures the philosophy of an "open mind" for the group as a whole.)

2. Everyone participates and no one dominates. (This is an excellent "rule" where there is a strict hierarchy. In these workshops, rank doesn't mean much.)

3. Avoid interrupting during Plenary; wait to be recognised, then talk. (This rule eliminates a lot of confusion and gives everyone to say their piece in peace.)

4. Set aside (temporarily) all special agendas except making an effective conservation assessment (This is to remind participants not to pursue their own vested interests... to try and be objective about the species and its habitat.)

5. Assume good intentions of other participants. (All too often, we have opinions of others that are not positive or correct- how many times have you heard someone say that some other conservation colleague was "not really interested", or "only trying to go abroad", or was "making money", etc. ! Assuming others' good intentions saves a lot of time, negative energy and allows us to trust. . which facilitates interaction.)

6. Don't reject ideas, rather offer additional options ... " Yes, and ..." (Have you ever been in a Workshop and contributed an opinion only to have someone say" No, that's not right"; or "that won't work," etc. You might have stopped contributing for some time, or for the duration of the workshop, instead, agoodfaciiitaatorsays'Yes, and... how about some other iaeas. Saying "Yes... and" doesn't mean the facilitator agrees with the idea but it does keep suggestions coming *and* avoids hurt feelings and drop outs.

7. Facilitator can call 'time out* --
—if discussion becomes circular and not progressive
—if an argument goes on too long and is unproductive -- if people are obviously tired and need a break
-- if an individual is destructive and needs taking aside & advising
— etc. any time the workshop gets "hung" and is not productive
(Getting agreement on "timeout" is important. Often people will get into a discussion that is going nowhere but they just can't stop. A facilitator is given the power by the group to say "time out" or "stop" and go on.

8. Stick to our schedule.... begin and end promptly.

9. Adjust process and schedule as needed to achieve goals.
(Hmmmm. Doesn't this contradict the above? No, agreeing as a group in advance to change the Agenda if needed and doing so as required is very different from individuals deciding to straggle in late!)

10. Primary work will be conducted in subgroups. (Obvious)

11. Agreements on recommendations are made by consensus.
(Head counts shouldn't be necessary for a reasonable group of adults.)

12. Agree to complete and review draft report by end of meeting.
(This helps keep participants physically at the workshop until the end and on to time schedule)

PHVA WORKSHOP PROCESS:

Principles and Concepts

The CBSG PHVA Workshop Process is based upon biological and sociological science. Effective conservation action *is* best built upon a synthesis of available biological information, but is dependent on actions of humans living within the range of the threatened species, as well as established international interests. Characteristic patterns of human behaviour appear cross-cultural:

1) in the acquisition, sharing, and analysis of information;
2) in the perception and analysis of risk;
3) in the development of trust among individuals; and,
4) in "territoriality" (personal, institutional, local, national).

Each of these has strong emotional components that shape our interactions. Recognition of these patterns has been essential in the development of processes to assist people in working groups to reach consensus on needed conservation actions.

The motivation for organising and participating in a PHVA workshop comes from a fear of loss as well as a hope for recovery for a particular species, subspecies, or population. Inherently we abhor species going extinct on our "watch." A commitment to the species is made by individuals who provide needed leadership. Effective and persistent action depends upon a bottoms-up approach, sometimes by participants who have rarely been a part of species conservation action planning. Usually a single person *is* key to initiating the workshop process. This person is essential for bringing stakeholders to a workshop which includes outsiders.

At the onset of the workshop, there is a consensus among the players on a general desired outcome : to prevent extinction and achieve species recovery. A collaborative process with power equalization of participants either *is* recognized as essential to achieve the recovery or needs to be achieved. Successful outcome depends on formulating a potential "win - win" strategy as a basis for developing management scenarios for participants and stakeholders whose interests and agendas usually differ. There is a need for an agreement to willingly pool resources, including new or unpublished information despite traditions of personal ownership.

The biological problems and threats to a particular species usually are complex and interactive with a need for diverse specialists. No agency or country encompasses all of the useful expert knowledge. Thus, there is a need to perceive outsiders as acceptable and useful as resources and analysts. It is important that the invited experts have reputations for expertise, objectivity, initial lack of local stake, and for active transfer of wanted skills. Local solutions (both people and political) are focus solutions. Workshop reports and outcomes are the property of locals and participants. Therefore significant commitment for the workshop process must be derived from local resources.

A corollary problem is the extraction of expert knowledge, the assumptions on which it is based and its use in the face of incomplete knowledge and uncertainty about its application. In our experience, perhaps 80% of useful information for species risk assessment and management planning which is in the heads of experts, is not published, and is not likely to be available in printed form for problem-solving. Modeling and simulations provide a neutral externalisation focus for assembly of information, identifying assumptions, projecting possible outcomes (risks), and examining for internal consistency.

Timely reports from the workshop are necessary to have impact on stakeholders and decision makers. Therefore, workshop Reports are completed and distributed quickly. This "mini-summary" is being sent to you to familiarise you with the process of PHVA, the problems facing the species being assessed and the potential for resolution of these problems in a systematic and scientific manner.

ISSUE 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 particular process of interest. In the case of the PHVA, modelling is a too! 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 symbols used in common signs. For example, the male/female diagrams on toilet doors are in fact simple models used to summarize and simplify important information. A more complicated day-to-day model is family financial planning. When we plan for financial savings 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 preformed a modelling exercise to come to some conclusions. Population models are just an extension of this process of compilation 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 model may look like this:

Population
Size 1994
= 100

¦
|
W
+ 10 Births + 3
Immigrants
- 7 Deaths • 2
Emigrants
|
|
W

Population
Size 1995
= 104

This simple process can be repeated year 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 population projections are data on birth rates, mortality, immigration, and emigration. This very simple model may be sufficient for some purposes. 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 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 in 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 a 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 litter 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 simulation 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 reliable expected average result, as well as an estimate of expected variations in the result, we need to run the simulation 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 which values 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 modelling 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 determination 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 multiple "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 generators.

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 differences 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 are inherently 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) dispersal but not dispersal rates (or probability) is stochastic in the VORTEX model. With respect to inbreeding, it is the individual mortality due to inbreeding that is stochastic (i.e., some inbred individuals live, others die, but all have a higher probability of mortality than do non-inbred individuals).

The same is 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 around the average population projections. Therefore, multiple model simulations (perhaps as many as several hundred) are needed to show the range, or distribution, of possible outcomes that reflect the 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
Number of offspring
Dispersal

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

Why Model?

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

- Population 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 governmental agencies by providing support for perceived population trends and the need for action. It helps managers to justify resource 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 its utility in some cases. If VORTEX is not considered appropriate, different models should be used. A "tool" kit of simulation 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 of the bio-spatial hierarchy must take into account linkages to other levels.

(1). The ECOSYSTEM and (2) COMMUNITIES 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. These approaches have been recommended as the foundation for effective conservation planning by the Biodiversity Convention 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 focus of management are the compositional elements of biodiversity: species and associated genetic diversity. Single species management can be undertaken both *in situ* and ex *situ,* taking into account the demographic and genetic status of the species.

The compositional elements of species are (4) POPULATIONS, (5) INDIVIDUALS, 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 both community structure and composition. Protected area borders are permeable to disease, invasive species, poaching, civil unrest, and climate change. Accordingly, a "fine filter** approach is 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 to bring all required expertise together to ensure a balanced integrated 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 conditions 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 coexistence depends on their individual limits and subsequent distribution along environmental gradients. On a geological scale, they could be viewed as relatively transient assemblages.

Species programs, 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 gardens, 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, sangai, 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 through 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 *lliamna 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 of offspring by related individuals. Inbred individuals have lower levels of heterozygosity, and correspondingly, higher levels of homozygosity.

Inbreeding depression is defined as the reduction of fitness (decreased survival, decreased fertility, less disease 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) known 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 advantage 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 white oryx, Mississippi sandhill 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, known inbred populations survive. In general, about 95% of rapidly inbred laboratory mice lines go extinct and all efforts to produce inbred livestock lines 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 vertebrates and plants. However, this is not necessarily the case. There are a number 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 levels 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 of 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 90% structurally abnormal sperm. In addition to 90% of the males being cryptorchid (one or both testes 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 variation by genetic drift resulting in decreased adaptability to changing environments and increased risk of extinction. This effect is important for the long-term evolutionary viability of the population.

In general, management should avoid inbreeding when there are no other management conflicts. Situations in which management to minimize inbreeding 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 a sufficiently large population to minimize genetic drift effects.

3. Growth rate of population 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 supplementation with unrelated stock, via translocation or from captivity.

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

3. Habitat modification that will increase population size and decrease its variation (food supplementation, artificial nest-sites, etc.).

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

C. Management of metapopulations.

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

The effect of inbreeding has considerable relevance to conservation. The numerous studies indicating 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 severe. Managers must determine what level of risk they are 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 metapopulation 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 increased 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, Mississippi 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. Inbred 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/adaptability causes extinction.

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 and 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 auditlike 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 from analogous situations and taxa may be substituted for unavailable 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 managers 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 less 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.

CONSERVATION BREEDING SPECIALIST GROUP

Species Survival Commission, IUCN

Mission and Major Activities

The Conservation Breeding Specialist Group is a global network of individuals with expertise in species recovery planning, small population biology, reproductive and behavioural biology, captive animal management, and other disciplines. Part of the Species Survival Commission (SSC) of the IUCN - The World Conservation Union, the Conservation Breeding Specialist Group advises the IU CN, SSC, and other SSC Specialist Groups on the intensive management of small populations in the wild and the uses of captive propagation for conservation, in accordance with the IUCN Policy Statement for Breeding.

As we approach the 21st century* the mission of the Conservation Breeding Specialist Group becomes increasingly urgent: *"to conserve and establish viable populations of threatened species through captive propagation programs and through intensive protection and management of small and fragmented populations in the wild"*.

CBSG acts as catalyst and coordinator for intensive management of threatened small populations with more than 600 members from more than 70 countries CBSG catalyzes coordination of conservation programs worldwide, working closely with institutions committed to species conservation via captive breeding as well as governmental and non-governmental organizations concerned with species and habitat conservation in the wild CBSG serves as a neutral stimulator and mediator in intensive species conservation management efforts providing information and technical assistance for a wide variety of programs. Because it does not represent any particular constituency, CBSG provides scientific objectivity to conservation conundrums over which individuals from different agencies may agonise, each unable to surrender their interests for political or hierarchical reasons.

<u>Conservation Assessment and Management Plans (CAMPs)</u>
CAMPs allow evaluation of all species and subspecies in a broad group (such as primates, cats, invertebrates on an island) to determine global priorities for intensive conservation, based primarily on status and distribution in the wild.

<u>Population and Habitat Viability Assessment (PHVA)</u>
PHVA is a process for assessing the extinction risk for a species and for developing management recommendations to enhance long-term survival. PHVA workshops are conducted in the range area of the species in collaboration with the wildlife agencies responsible., Also included in the PHVA process is an evaluation of the status of the species in captivity, plans for reintroduction, and problems requiring collaborative research. More than 70 formal PHVA workshops have been carried out since 1990 Among the species for which PHVAs have been conducted since 1991, five of them have been in India; Manipur Brow-antlered deer, Asiatic lion, Lion-tailed macaque, Indian rhino, Indian gharial.

With the goals of prevention of extinction and recovery in the wild, training, using materials in the regional language as well as English, is provided for local participants in small population assessment and management, record keeping systems, and the concepts of regional and local collection planning for conservation Implementation of programs may include, assistance with national or regional zoo collection planning for endangered endemic and regionally endangered species, development of a genome resource bank, establishment of a captive propagation program, support of a research program, providing special training, or assisting a reintroduction program.

HISTORY of the Conservation Breeding Specialist Group, SSC, IUCN & CBSG, India

The "Captive" Breeding Specialist Group began assisting zoological collections to play a more meaningful role in conservation of species in 1981, about the same time that Dr. U. S. Seal, an American conservation biologist became the Chairman. Dr. Seal developed a systematic breeding programme for Siberian tiger, taking into consideration the genetic and demographic characters which would insure its long-term survival in captivity and *its* viability as a support to *in situ* populations. He also developed a comprehensive, computerised record system for zoos which is now internationally accepted and initiated a review of Studbooks. Dr. Seal could be called the "father" of modern zoo management.

A few years later, CBSG helped the Wisconsin Wildlife Department recovery programme for the critically endangered black-footed ferret, using computer simulation modelling to determine the probability and time till extinction and experts on breeding viverrids and mustelids as advisors to develop the captive breeding program, on which the success of the recovery subsequently hinged. This programme became a model and over the years, wildlife managers, nongovernmental organizations, governments, and the private sector in addition to the zoo community became more integrally involved in CBSG s activities. These individuals form a network which provides an interdisciplinary vehicle for communication and collaboration between conservation activers. As a result, the name was changed from "Captive" to Conservation Breeding Specialist Group. One of CBSG s primary strengths is that it has brought a scientific approach to defining problems and determining management strategies for conservation activities, both in captivity and in the wild. Another is that CBSG has used "group process" tool and principles of human dynamics to run their workshops, to ensure interactive, dynamic communication designed to bring about consensus among all the stakeholders

In 1991, CBSG s first satellite organisation, CBSG India, came about as the result of a lecture and discussion on International cooperation at the Wildlife Institute of India Zoo Management Course. It was thought that a Regional Branch of CBSG could be started to involve people locally, keep an identity with the international group and spread the information farther and deeper. Dr. Seal readily gave his consent for CBSG, India to form and to develop its own working style and logo with India species. CBSG, India attracted more than 400 members in its first few months with over 95% of them from the forest, wildlife, university and zoo community.

CBSG, India till date has conducted 6 PHVA's and one CAMP Workshop described elsewhere in this booklet using the tools and strategies evolved by CBSG. Indian PHVAs have their own style nontheless:

1. Briefing material and Reports all emanate from India so that the exercise from start to finish is primarily from Indians; 2. Additional copies of Briefing books and Reports are circulated widely to zoos, universities, Zoological Survey of India and others who require this compiled material; 3. Training Workshops are often held in connection with PHVAs; 4. Educational material is developed for Indian PHVAs and circulated to zoos and NGO's which are involved in educating the public.

CBSG, India itself has Special Interest Groups for species and subjects such as Education, Veterinary medicine, White-winged wood duck**;** Invertebrates, Amphibians, Rare plants, etc. which hold several workshops and training courses a year and bring out special publications.

CBSG, India *is* the only CBSG Satellite to date, although others are fast coming up in Indonesia, Mexico, China and Costa Ricca and expected to be fully operational by the end of 1995.

Zoo Outreach Organisation is a Positive, Constructive, Practical, Scientific, Sensible and Sensitive Conservation, Education, Research and Animal Welfare Society. It was founded because we felt the potential of zoos in India was not being fully recognised or realised by the public, by politicians, by policy makers, or by professionals (educators, scientists, managers. Much of what you hear about zoos is negative and critical, we started Z.O.O. *to be a positive force FOR zoos.*

Z.O.O. reaches out to zoo, wildlife, welfare, and veterinary personnel to give them things they need, to improve their animal management... .to the public to instruct them how to behave in the zoos and how to help their local zoo... to teachers and schools to help them learn how to use the zoo to teach conservation . . . to government officials to help them realise the importance of zoos so that they would facilitate better funding and smoother administrative functioning. Z.0.0. operates in a positive and constructive manner, attempting to *fix the problem, not the blame.* Zoo Outreach Organisation has evolved *the* role of a neutral link between individuals, organisations and institutions involved in widlife and zoo conservation activities to ensure that all are exposed to the most up-to-date information.

Z.O.O. is a registered society in India with members all over the country and a working office in Coimbatore, T. N. Zoo Outreach Organisation publishes two monthly magazines - ZOOS' PRINT and ZOO ZEN.

Z.O.O. represents the Captive Breeding Specialist Group, SSC, IUCN. - C.B.S.G., India. Z.0.0. and C.B.S.G., India jointly act as a catalyst and liaison to organise International Conferences and Symposia concerning Indian species *IN INDIA* where they should be. Z.O.O./CBSG, India has organised six major Population and Habitat Viability Analysis Workshops and one Conservation, Assessment and Management Plan Workshop in India in collaboration with other organisations in India and abroad, Z.O.O./CBSG, India has organised veterinary and husbandry workshops with special reference to advanced reproductive technology about cervids and felids.

Z.0.0. is an international partner of several like-minded organisations abroad, forming a link for mutual communication and collaboration*

Z.0.0. DOESN'T criticise zoos or zoo personnel. Z.O.O. DOESN'T retain members who criticise zoos. Z.O.O. DOESN'T criticise the government (much), although we may occasionally *REMIND* them if something crucial has been overlooked!

Z.O.O. aims to do anything that will help promote the "three C's of Conservation" (Communication, Co-ordination, and Co-operation) and to discourage the "three E's of Extinction" (Envy, Egotism, Elitism).

Z.O.O. Networks*

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FROM: FAX: 02-Jan-91 Wed 03:28 PAGE: 01

cc:-ultio

केन्द्रीय चिड़ियाघर प्राधिकरण
Central Zoo Authority

S.C. SHARMA
MEMBER SECRETARY

D.O.No. 7-2/95-CZA June 26, 1995.

Dear Dr. Sea1 ,

Swamp deer or Barasingha, at one time was found in most of the Sub Himalayan forests in good numbers. Due to variety of factors the population of Barasingha has declined sharply in last 2 - 3 decades. Ministry of Environment and Forests, has therefore, decided to hold a PHVA Workshop, to pin-point the factors that have resulted in the decline of Barasingha population. The Central Zoo Authority has been asked to coordinate this Workshop through Wildlife Institute of India, CCMB, Zoo Outreach Organisation and the Forest Department of Uttar Pradesh, Assam and Madhya Pradesh. The Barasingha population of Assam and Madhya Pradesh is considered to be genetically different from the Barasingha population in Uttar Pradesh. All the three populations are considered to be separate sub-species of Cervus duvauceli. You have always shown keen interest in the wildlife of this country. In past you have successfully conducted PHVA Workshops on Sanghai, Liontailed macaque, Asiatic lion and Indian rhino.

It is my privilege to invite you as Chairman of the Conservation Breeding Specialist Croup to come and conduct the PHVA Workshop from 3rd to 6th July, 1995 at Wildlife Institute of India, at Dehradun.

I thank you in anticipation for your positive reply and looking forward to see you again at Dehradun.

With best regards.

Yours faithfully,

(S.C. SHARMA)

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Fax - 612-432-2757

Bikaner House. Shahjahan Road, New Delhi-110011. Phone: (O)381585 (R) 6917139 Fax 011-386012

R.S.BHADAURIA
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उत्तर प्रदेश
Principal Chief Conservator
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LUCKNOW (INDIA)
अर्द्ध शा० पत्र संख्या - 816/38-34

तार : चीफोर लखनऊ
दूरभाष [कार्यालय : 283356
[आवास : 243015

लखनऊ, दिनांक June, 9-15 1995

Dear Dr. Seal,

The Barasingha (Cervus duvauceli duvauceli) is almost a symbol of wildlife in the State of U.P. as it was so prevalent in the Tarai and other areas of U.P. Over the past few decades, several populations have declined drastically both in number of populations as well as individuals. There are areas where the species has become extinct.

There are two more sub species of Barasingha one in Madhya Pradesh (Cervus duvauceli branderi) and the other in Assam (Cervus duvauceli Ranjitsingi) which have also suffered losses as a result of various factors associated with growth of human population and deterioration of habitat.

I am aware of the work of the Conservation Breeding Specialist group in conducting workshops to assess the risk of extinction to various species around the world. I understand that the population and Habitat Viability Workshop (P.H.V.A.) and Computer Simulation modelling can give insights into management options, helpful in preparing a management plan for these species.

I will be pleased if you could kindly come and conduct a PHVA Workshop for Barasingha in connection with the proposed Traing in Small Population Biology at W.I.I., Dehradun.

Soliciting confirmation.

With regards.

Yours

(R.S.BHADAURIA)

DR. U.S. SEAL
12101 JOHNNY CAKE RIDGE ROAD
APPLE VALLEY, MINNESOTA 55124-8151
U.S.A.

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Preliminary Information Sheet -- Barasingha PHVA

(Cervus duvauceli branderi : hard ground barasingha)

Contributor's Name: RAJESH GOPAL, IFS

Address: Conservator & Field Director
Project Tiger (Kanha), MANDLA (MP) 481661

Target population location *:

Is target population located in a: PA [✓] (KANHA N.P.) Non-PA [ ] RF [ ] Others [ ]

Habitat characteristics: (vegetation type, habitat information and habitat preferences of target population) Valley grasslands, grasslands with miscellaneous and Sal.

Population estimates:

100 years ago	50 years ago	20 years ago
3000 (approx)	600 (approx.)	165

10 years ago	5 years ago	Present
479	525	366

Population density estimate:

Habitat capacity estimate (has carrying capacity increased or decreased in the last 20 or 50 years? If yes, by how much?): Has increased, almost five times owing to the availability of heterogenous grass flora as a sequel to village relocation.

Is habitat protection status of this area likely to change in the next 5, 10 or 20 years: How?

Territoriality (home range, season): Show local seasonal migration within the home range.

Maximum age to which the animal lives: Males [around 9] yrs. Females [approx. 10] to 12 y.

Adult sex ratio: Male (1) : Female (2) : Unknown ( )

Age of first reproduction:

	Earliest	Average
Females:		2 yrs.
Males:		2 yrs.

* If you have information about more than one (unconnected) population please copy this form and fill seperately

Litter size: (Have you ever noticed twins? If so how many times?)

Length of time between births Minimum [ ] Maximum [ ] Average [1 year]

Approximate number of adult females: [45 %]

Approximate number of mature females in breeding pool: [32 %] (pregnant does)

Fawning season: August – September

Age at which animals stop reproducing: Male [8 yrs] Female [8 to 10 yrs]

Number of populations in the area: [3] (Geographically isolated)

Incidence of animals migrating: (your observations) Show seasonal migrations for feeding, reproduction

Age at migration: Male [ ] Female [ ] (All age groups of both sexes participat

Mortality rates in percentages per year:

Neo natal	Juvenile	Adult
34.6 %	23%	42 %

Source of mortality %: Natural [ ] Poaching [ ] Disease [ ] Drought [ ]

Vehicle [ ] Seasonal [ ] Migration [ ] Fights [ ] Others [Predation, Lack of highg]

Please list the natural disasters or catastrophes which have affected reproduction or mortality:

Shrinkage of wilderness & lack of adequate swamps with high grass which are essential for refuge & fawning.

Please return this form to: Zoo Outreach Organisation, CBSG, India
85, Bharathi Colony, (PB 1683)
Peelamedu, Coimbatore 641 004

Rajesh Gopal.
Signature

Preliminary Information Sheet -- Barasingha PHVA

Contributor's Name: Dr Vijay Prakash Singh

Address: Jaidei Nagar (Rajgarh) Lakhimpur Kheri 262701

Target population location *: Dudwa Tiger reserve

Is target population located in a: PA [✓] Non-PA [ ] RF [ ] Others [ ]

Habitat characteristics: (vegetation type, habitat information and habitat preferences of target population) Grassy land, Sandy, ~~[illegible]~~ Swampy, dandying area.

Population estimates:

100 years ago	50 years ago	20 years ago
	Ten thousand	Four thousand

10 years ago	5 years ago	Present
Two thousand & five hundred	Two thousand	One thousand & five hundred

Population density estimate:

Habitat capacity estimate (has carrying capacity increased or decreased in the last 20 or 50 years? If yes, by how much?): decreased

Is habitat protection status of this area likely to change in the next 5, 10 or 20 years: How?
— No

Territoriality (home range, season):

Maximum age to which the animal lives: Males [Twenty years] Females [Twenty years]

Adult sex ratio: Male (30%) : Female (40%) : Unknown (30%) (yearlings)

Age of first reproduction:

Females:	Earliest	Sixteen Month	Average	Two years
Males:	Earliest	Two years	Average	3 to 5 years

* If you have information about more than one (unconnected) population please copy this form and fill separately.

V. P. Singh
Jaidei Nagar
(Rajgarh)
Lakhimpur Kheri

Litter size: (Have you ever noticed twins?. If so how many times?) 1 C

Length of time between births Minimum 10 months Maximum 15 Months Average 12.5 Months

Approximate number of adult females: 2500

Approximate number of mature females in breeding pool: 600 to 650

Fawning season: May & June

Age at which animals stop reproducing: Male 15 years Female 10 to 12 years

Number of populations in the area: 1500

Incidence of animals migrating (your observations). Yes

In Sathiana Block of Dudhwa Tiger reserve

Age at migration: Male 3 to 5 Female 2 to 4

Mortality rates in percentages:

Neo natal	Juvenile	Adult

Source of mortality %: Natural [ ] Poaching [ ] Disease [ ] Drought [ ]

Vehicle [ ] Seasonal [ ] Migration [ ] Fights [ ] Others [ ]

Please list the natural disasters or catastrophes which have affected reproduction or mortality:

Please return this form to: Zoo Outreach Organisation, CBSG, India
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THE INAUGURAL SPEECH OF SHRI S.C. DEY, ADDL. IGF ON THE WORKSHOP OF SWAMP DEER, HELD IN WILDLIFE INSTITUTE OF INDIA ON 3RD JULY, 1995.

I am glad to be here today on the date of inauguration of the Workshop of Conservation of Swamp Deer specially its population and habitat viability assessment organised by Ministry of Environment & Forests through collaboration of Central Zoo Authority, Wildlife Institute of India, CBSG India and the State Forest Departments. I am, however, sorry to see that not many senior officers of the State Forest Departments are available here to make the Workshop meaningful.

As per our record Swamp Deer existed in undivided India in the alluvial plains of Indus, Ganges, Bramhputra to Mahanadi and North Godabari basins in central India. The States in which its distributions were reported are Sindh and Punjab province, Uttar Pradesh, Bengal, Assam, Bihar Orissa, Madhya Pradesh and Andhra Pradesh. Currently, however, Swamp Deer population is reported in the wild only in 5 areas of Uttar Pradesh, one area of Madhya Pradesh and 2 areas of Assam.

The causes of shrinking or decline of Swamp Deer population in India can be enumerated as follows :

1. Reduction/destruction of habitat.
2. Poaching for sports or meat.
3. Predation by wild carnivores.

The main causes leading to reduction/destruction of habitat are -

(a) construction of dams and submergence of alluvial grass lands,

(b) extension of cultivation;

(c) encroachment/intrusion in swamp deer habitats; and

(d) mono-culture plantation to convert grass lands.

Though exact estimation of the population of swamp deer in the historic past is not available on record certain studies indicate that the population of swamp deer in India in early 60s was anything between 1800 to 2100. Estimation done in 1991 indicates the population level to be anything between 2100 to 2200. This will indicate that in spite of the pressure on habitat, introduction of appropriate laws, commitment of the forest officers to the cause of wildlife conservation and appropriate implementation of the action programme has kept the population of swamp deer more or less stable over a period of 30 years even though the pressure on the habitat during this period has increased considerably due to explosive human population and growth of live stock population in and around protected areas.

The captive population of swamp deer is reported to be 61 as per available figures of early 1990s. There are five populations covering Delhi Zoo, Chatbir Zoo,Mysore Zoo, Kanpur Zoo and Lucknow Zoo, Lucknow Zoo having the largest population numbering 32.

It will be appropriate for me to introduce at this stage the role of CBSG in promoting ex situ conservation of species, and what does PHVA means to us. If I remember correctly the CBSG was established in 1979 for limited objective of zoo liaison and coordination. Dr. U.S. Seal took over as the Chairman of the Organisation in 1981 and in 1991 considering the importance of rich bio-diversity of India CBSG India was opened as first satellite organisation of CBSG mainly due to the efforts of Ms. Sally Walker of Zoo Outreach Organisation. Since creation of CBSG India, 5 workshops have been held by this Organisation with internation support. These are -

(i) 1992 - Brow Antler Deer (Mysore). Karnataka.

(ii) 1993 - (a) Lion tailed macaque (Madras), Tamil Nadu.

(b) Asiatic Lion (Baroda), Gujarat.

(c) Great One-Horned Rhino (Jaldapara),

(iii) 1995 Gharial (Gwalior), Madhya Pradesh.

Thus the current workshop is the 6th workshop in a row after CBSG India came into existence about 4 years back from now. The CBSG which originally stood for captive breeding specialist group was renamed as Conservation Breeding Specialist Group in the year 1994 to have wider coverage of issues, and PHVA became a major subject of activity of this group.

I understand globally not less than 50 PHVA have been held in last 3 years and they are receiving more and more attention in current times. The PHVA helps us primarily in the 5 broad understandings :

(1) Assembling current information of the species in one place.

(2) Bringing in groups of experts together for discussion and dissemination of ideas for comprehensive approach in future.

(3) Objective assessment of the risk to the species as it exists today and the future of the species with the evolving scenario.

(4) Preparing an objective report for taking appropriate policy decision.

(5) Suggesting a tentative action programme for the conservation of the species in small population both ex situ and in situ.

The question comes up repeatedly about the value of ex situ conservation in the matter of conservation of the species in the wild, and in this connection the subject of reintroduction of captive bread species in the wild becomes relevant. Unfortunately, however, certain stray experiments which were carried out in the past for the reintroduction of some species specially lion in the earlier part of this century in Shivpuri area of Madhya Pradesh and Chandraprava area of Uttar Pradesh, which were done without proper initial preparation and in built provision of follow up action and resulted into failure, are often quoted by many conservationists as impractibility of reintroduction of captive population specially the bigger pre-dators, into the wild. It will, however, be pertinent to mention here that we do have successful stories of reintroduction of quite a number of species in the wild and these include - (i) 3 species of crocodiles, (ii) Spotted Deer (iii) Hollock Gibbon (iv) Turttles (v) Rhinos, etc.

It will, therefore, be wrong to say that reintroduction of captive species in the wild is not possible. However, I fully agree that the reintroduction of the species should be done only under certain conditions, and the major conditions governing such reintroduction must take into account the following :

(i) Identification of previous cause of decline like habitat loss, hunting, pollution, disease, competition from other species and predation etc.

(ii) Sustainable habitat and landscape requirements which means there should be adequate safeguard for the continuity of the habitat over a long time frame.

(iii) Sufficient carrying capacity for a viable population - to accommodate not only the presently introduced population but also expanding population through breeding over years .

(iv) Attitude of local people. This is crucial because no programme of reintroduction can be successful without the support of the local communities.

Certain steps which are necessary in general and are required for satisfying such conditions of reintroduction are

(i) A multi-disciplinary approach to involve all sectors of technically qualified manpower in the process of reintroduction.

(ii) An appropriate feasibility study and research input including taking stock of previous introduction programme, if any, and choice of site for present reintroduction.

(iii) There should be a written scheme of proposed programme approved at the highest level of government so that the change of officials at local level do not jeopardise the continuity of the programme.

(iv) Post release monitoring of the animals so that changes as required due site and situation specific conditions can be adopted without delay on a sound information base.

(v) Launching of a large scale public education and awareness programme to convince the local people about the necessity of such reintroduction and to educate them about the ways and means for living in harmony with introduced species in the area.

I would not like to go on elaborating on these. I expect that the workshop will come out with a concrete action plan with respect to survival of the species in the wild for the benefit of conservation and enjoyment of the people of our time and the generations beyond. I wish the workshop a success.