TRANSLOCATION OF JAVAN RHINOCEROS?

a decision-making analysis

Dr. H.H.T. Prins

Research-fellow

Royal Netherlands Academy of Arts and Sciences

Senior Scientist

Zoölogisch Laboratorium

University of Groningen

The Netherlands

P.O. Box 14

9750 AA Haren

The Netherlands

- January 1991 -

SUMMARY

A proposal to capture a number of Javan rhinocerosses from Ujung Kulon (Java, Indonesia) can only be justified in terms of increased survival chances for the species, increased numbers, and halting of the loss of genetic variability. Commercial or educational justifications are irrelevant in the situation where a species is severely reduced in numbers.

In the report of the Captive Breeding Group (IUCN) it is unclear why a captive stock should be held outside the Republic of Indonesia, and justifications for this are not given.

A plan to capture such rare animals should have been underbuild by providing data to chose the optimal strategy within the terms of justification, which are increased survival, increased numbers, and reduced risk of extinction. If these calculations are not shown, then PHPA, IUCN, or WWF should not agree with any plan to seriously threaten a number of individuals with death or injury during a capture plan.

The proposed rhino operation has as desired effects:

- translocating animals reduces the risk that both groups will go extinct,
- when more animals are translocated to a zoo or to another area, the chance that they will fail to reproduce decreases when the translocated population increases.

However, the undesired effects are:

- capturing results in fragmenting the population, and thus an increased reduction of the overall genetic variability,
- capturing results in a decreased population in Ujung Kulon, which increases the risk of extinction in the wild,
- capturing results in losses of unique, rare, animals during capture and transport,
- chances that animals will reproduce in captivity are small.

In this paper I have made a series of calculations regarding 17 different scenarios (no capture, capture of 2, 5, 10 or 20 animals; release in captive stock, release in a well-protected nature reserve on Sumatra) to weigh the desired effects against the undesired ones. Optimality of a strategy is defined in this paper in terms of conditional genetic variability, conditional numbers, and chance of survival.

The optimal strategy is removing 8 - 10 animals from Ujung Kulon and releasing them in a well protected nature reserve on Sumatra. The worst strategy is removing 20 animals into a captive stock (a zoo); the captive stock scenario is always worse than no capture what-so-ever.

This means that when PHPA concludes that animals could be captured from Ujung Kulon, PHPA first has to prepare a well-protected large site on Sumatra - properly fenced and guarded, and with the proper vegetation - before the animals can be captured. The site should be at least large enough for allowing the new established population to grow to 20 or 30 animals, thus it should be approximately 12000 to 18000 hectares (needing a fence of approximately 45 km to 55 km). The animals should be released immediately after transport, and not be held in captive stock for breeding, because this diminishes the chance that they will breed and survive as is shown by the present analysis.

THE PROBLEM

In a recent report of the Captive Breeding Specialist Group of the IUCN on the Javan rhinoceros Rhinoceros sondaicus based on a population viability analysis workshop held 5-7 June 1989 at Bogor, Indonesia, a number of problems regarding this species and some solutions are discussed. The report concentrates on:

- the supposed loss of genetic variability,
- the assumed lack of recruitment,
- the assumed stabilization of the population at very low numbers, and

- the catching and transportation of approximately 50% of the whole population from Java (Indonesia) to (American) zoos or Indonesian captive stock.

The report provides much suggestive reading, leading to the apparently unescapable conclusion that the best thing that can be done to save the Javan rhino from utter extinction is to translocate a considerable number of the population from Ujung Kulon into captivity. One such place should be on Java, one on Sumatra (from where the animals can be released into the wild again whenever there are - unrealistically - high numbers in captivity (for example to Way Kambas on Sumatra), and one place should be outside the Republic of Indonesia. It is interesting to read this in the recommendations, as a discussion on this last point cannot be found in the minutes of the meeting.

Much theoretical information about genetic loss of small populations and about the risks of extinction is presented, but a real discussion of pros and cons of the proposal is not given. Most serious is that no cost/benefit analysis (in terms of genetic variability and expected numbers) is made of several options, and that a proper decision-making analysis is not presented.

The options, of course, are (i) no capture what-so-ever, (ii) translocation to another protected area, and (iii) translocation into a captive holding area; options (ii) and (iii) have different variants regarding the numbers of rhinoceros to be captured.

GENETIC LOSS OR GAIN?

Contrary to what is suggested (but not stated) in the report, capturing animals from the small population of Javan rhinoceros from Ujung Kulon does not improve the genetic variability status of the species. To the contrary: capture results in two (or even more) fragmented populations, which results in an increased genetic drift and thus increased loss of genetic variability. This is shown in Table 1:

Ujung Kulon		Captive		Joint populations
N_e	variance	N_e	variance	variance
40	0.951	0	0.000	0.951
38	0.936	2	0.237	0.918
35	0.931	5	0.590	0.895
30	0.919	10	0.774	0.885
20	0.881	20	0.881	0.881

Table 1. Genetic variance after 4 generations, relative to the genetic variance at t = 0. The calculation is done, of course, under the assumption that the captive stock will breed.

The genetic variance declines by genetic drift, and is calculated as:

$$V_g(t) = V_g(0) \times (1 - 1/(2N_e))^t,$$

in which V_g is genetic variance, t is the generation, and N_e is the effective population size. In the calculation the sampling factor is taken into account when the initial population is started (multiply with $1 - 1/(2N)$). The joint variance can be approximated by:

$$V_g(\text{joint}) = \frac{(n_1 - 1) \times V_g(\text{pop. } 1) + (n_2 - 1) \times V_g(\text{pop. } 2)}{(n_1 + n_2 - 2)}$$

in which the subscripted suffixes 1 and 2 stand for the first and second population, respectively, and n denoted the population size.

So, capturing animals from a small population, and translocating them to elsewhere results in two (or even more) smaller populations, and the loss of genetic variance is increased. This is basically contrary to what conservation is about: the conservation of genetic variability.

RISK ASSESSMENT

In the wild, animals face extinction, for example because of wide-spread break-down of law-and-order. How does one attach a risk to these types of events? The only way is to use the past to predict the future. Major break-downs occurred the last 100 years in 1942 (Japanese occupation) and 1965 (coup attempt): a chance of 2% per year. However, in both cases the rhino was not wiped out; during the Japanese occupation when trophy hunting could have been started in Ujung Kulon, the Dutch warden (Hoogerwerff) together with Indonesian staff continued protecting the area on Japanese orders. Thus, I assume the risk of extinction for a population of 40 in the wild to be about one-tenth of the named 2% per year, so 0.02% per year. When the population becomes smaller, the risk will increase, and I assume the risk to be twice as large when the population is two times smaller.

However, because risks cumulate over the years, the risk that the wild population will go extinct over a 60 years time-span (4 generations, just as in the other calculations) is much larger. Survival chance can be calculated as $(1 - 0.002)^{60}$ for N = 40, or for N = 20 as $(1 - 0.004)^{60}$ (and in a similar way for other population sizes). The outcomes are shown in Table 2:

Number in the wild:	40	38	35	30	20
Survival chance :	0.887	0.881	0.872	0.852	0.786

Table 2. Survival chances in Ujung Kulon for the coming 60 years based on an assessment of risk.

So, survival chances in the wild decrease when animals are removed from Ujung Kulon and when the population would not compensate for these losses (for example, because protection is not good enough).

Capturing animals from the wild, and transporting them, is risky under all conditions but especially when only little or no experience is available. Javan rhinos have been captured in the past but not legally in recent times, so little information is available about safe capture procedures and handling techniques. Yet, it is clear from capturing the related Sumatran rhinoceros that losses generally are high, and in the order of 30%. After they have been captured, the animals have to be transported to the new area. Again losses can occur, and I assume the risk to be 10%. Once the animals arrive at their new place, there is a chance that only males or females are produced. I have calculated this chance under the assumption that females constitute 50% of the translocated animals and that each female produces 3 offspring her life time, which is not unreasonable but optimistic.

Because all these chances are independent of each other, they have to be multiplied to estimate the overall probability that the translocated rhinos will be there still after 60 years.

Number of animals:	0	2	5	10	20
Capture survival	-	0.7	0.7	0.7	0.7
Transport survival	-	0.9	0.9	0.9	0.9
P(sex balanced)	0.000	0.875	0.992	1.000	1.000
P(survive 60 yrs)	-	0.786	0.786	0.786	0.786
Overall chance	0.000	0.433	0.491	0.495	0.495

Table 3. Chances for rhinos translocated to another nature reserve to survive for 60 years (4 generations) under the assumption that the population is not growing and that the chance to survive is not further dependent on the size of the population. P stands for probability.

The scenario in Table 3 is still an optimistic scenario, because I have assumed that the probability to survive is independent of population size. I don't believe this myself very much, so a more pessimistic scenario is presented in Table 4.

Number of animals:	0	2	5	10	20
Capture survival	-	0.7	0.7	0.7	0.7
Transport survival	-	0.9	0.9	0.9	0.9
P(sex balanced)	0.000	0.875	0.992	1.000	1.000
P(survive 60 yrs)	-	0.086	0.380	0.618	0.786
Overall chance	0.000	0.047	0.237	0.389	0.495

Table 4. Chances for rhinos translocated to another nature reserve to survive for 60 years (4 generations) under the assumption that the population is not growing. P stands for probability.

When the rhinos are transported to an overseas zoo, one can have the optimistic idea that law-and-order will not break down there. Whether this will never occur in a country like the United States is unknown, and the same applies to the risk of an epidemic in such a zoo. In the present analysis I have ignored both risks. However, one cannot ignore the risk that the rhinos will fail to breed. The Javan rhino has to my knowledge never reproduced in captivity, and the experience with the Sumatran rhino is very disencouraging: some pregnant captured animals produced offspring but real breeding in captivity is extremely rare. Also the experience with Black rhinos <u>Diceros bicornis</u> is far from positive. Hence, I estimate the chance that reproduction will occur (at least two calves born per female) during one generation to be only 5% (meaning that the chance they produce one surviving offspring equals 22.4%). The chance on successful reproduction during one generation then depends on the number of females in captivity; for 2 animals there is one female, so the chance that this does not happen is 0.95^{nf} in which nf stands for the number of females. During 4 generations, when there is one male and one female in captivity the chance that they successively will breed is 0.000 ,i.e. $(0.0050)^4$. When there are 20 animals in captivity, the chance is $(0.401)^4$ which is 0.026. Even with a very optimistic scenario of 10% chance that the animals breed and produce at least two young (31.6% chance they will produce one surviving young), the chance that they will do it for four generations decreases quickly when there are few animals in captivity. The zoo scenario is a risky one, as is shown in Table 5:

Number of animals:	0	2	5	10	20
Capture survival	-	0.7	0.7	0.7	0.7
Transport survival	-	0.9	0.9	0.9	0.9
P(sex balanced)	0.000	0.875	0.992	1.000	1.000
P(reproduce)	-	0.000	0.000	0.003	0.026
four generations at 5% chance on 2 young per female					
Overall chance	0.000	0.000	0.000	0.002	0.016
Capture survival	-	0.7	0.7	0.7	0.7
Transport survival	-	0.9	0.9	0.9	0.9
P(sex balanced)	0.000	0.875	0.992	1.000	1.000
P(reproduce)	-	0.000	0.000	0.028	0.180
four generations at 10% chance on 2 young per female					
Overall chance	0.000	0.000	0.000	0.018	0.113

Table 5. Chances for rhinos translocated to a zoo to reproduce during 4 generations (60 years) under the assumption that the population is not growing. P stands for probability. Two scenarios are shown; the first that every female has a chance of 5% to produce at least 2 offspring during her life time, the second scenario is that she has a chance of 10% to do so.

THE NUMBER OF RHINOS IN THE FUTURE UNDER DIFFERENT REGIMES

If the whole operation of capturing, translocating, and breeding of rhinos is successful, how many rhinos can be assumed to live in 60 years from now? This depends on the intrinsic rate of growth of the population, r. The formula to calculate the total number after t generations is then:

$$N_t = N_0 \times (1 + r)^t \quad ,$$

in which N_t is the number after t generations, and N_0 is the number with which the population starts. As a matter of fact, only breeding animals should be taken into account (which is approximately the same as the effective population size that we used for calculating the genetic variance).

I have estimated the expected numbers as specified in Table 6a.

N left in Ujung Kulon	estimated r	N at t = 4
40	0.010	41.6
38	0.025	41.9
35	0.050	42.5
30	0.100	43.9
20	0.200	41.5

N in zoo	estimated r	N at t = 4
0	0.000	0
2	0.010	2.1
5	0.025	5.5
10	0.050	12.2
20	0.050	24.3

N in nature reserve	estimated r	N at t = 4
0	0.000	0
2	0.010	2.1
5	0.025	5.5
10	0.050	12.2
20	0.100	29.3

Table 6a. The expected number of rhinos in the wild on Ujung Kulon, or in captivity, or in a nature reserve on Sumatra. I have assumed the population in Ujung Kulon to increase its growth rate when animals have been removed. For the captured animals I have assumed that a very small group will show a slower growth rate than a slightly larger one (e.g., in a small group there will

be compatibility problems). I have taken 10 and 20 animals equal for the zoo group because I assume a group of 20 to be split into two groups.

The expected number to breed in captivity are, as a matter of fact too high estimates with the two scenarios of 5% chance or 10% chance for a female to produce 2 surviving calves during her lifetime. If capture risk (30% loss) and transportation risk (10% loss) is taken into account, the expected numbers are as shown in Table 6b:

N captured	N in zoo	assumed r	N at t = 4
0	0.0	0.05	0.0
2	1.26	0.05	1.53
5	3.15	0.05	3.83
10	6.30	0.05	7.66
20	12.60	0.05	15.32

N captured	N in zoo	assumed r	N at t = 4
0	0.0	0.10	0.0
2	1.26	0.10	1.84
5	3.15	0.10	4.61
10	6.30	0.10	9.22
20	12.60	0.10	18.45

Table 6b. The expected number of rhinos in captivity, taking into account capture loss and transportation loss, with a chance that a female produces 2 surviving offspring of 5% and 10%, respectively.

After 4 generations the apparent growth rate of the population is negative under the 5% chance scenario (apparent r = -0.006) and also under the 10% chance scenario (r = -0.002). After 8 generations (120 years!), the apparent r for the 5%

chance scenario is still negative (r = -0.009) and for the 10% chance scenario positive (r = +0.04). I have not used Table 6a in my calculations, because of some optimism at my side regarding the captive stock scenario. For the same reasons I have not taken into account here transportation risk and capture risk when calculating the expected numbers in a nature reserve. The calculations show that the expected results of any operation are extremely sensitive to the risks of capture and transporation.

DECISION MAKING, JOINT PROBABILITIES AND CONDITIONAL VALUES

From the different tables, one shall have gotten the impression that the risks are large and that capturing animals often results in undesired effects but also desired effects. This is normal in, for example, economics and business decision making. The pros and cons have to be weighed, and this is what is seriously missing in the report of the Captive Breeding Group. To recapitulate, the desired effects are:

- translocating animals reduces the risk that both groups will go extinct,
- when more animals are translocated to a zoo or to another area, the chance that they will fail to reproduce decreases when the translocated population increases.

However, the undesired effects are:

- capturing results in fragmenting the population, and thus an increased reduction of the overall genetic variability,
- capturing results in a decreased population in Ujung Kulon, which increases the risk of extinction in the wild,
- capturing results in losses of unique, rare, animals during capture and transport,
- chances that animals will reproduce in captivity are small.

But how do we have to weigh the desired effects against the undesired ones? And how do we make the best decision? The answer to this can be found in so-called conditional values as they are calculated in business decision making. If the parameter we want to realize has a certain value (e.g., buying a commodity - the commodity has a value equal to the prize), but when there is a chance that it cannot be realized (e.g., the commodity will not be delivered), then the conditional value is equal to the product of the value and the chance that we obtain it.

The three parameters we are most interested in case of the Javan rhino (or other rare animals) are (i) genetic variability, (ii) total numbers, and (iii) survival chance. These three parameters have to be maximized simultaneously. In case of such a rare animal, the chances of making (maximum) monetary profits or educational values for the public or what else one may think-up are totally irrelevant.

In making our decision, we have to chose for the strategy that maximizes the conditional value of genetic variability and total numbers simultaneously.

In the calculations regarding different strategies, joint probabilities play a significant role. Joint probabilities are the result of two marginal probabilities interacting in the following way. For example, when the chance that rhinos would go extinct on place A is 0.7, then the chance it will not go extinct is 0.3. These values for place B are, respectively 0.6 and 0.4. We now can make the following schedule under condition that the risks in the two places are independent of each other:

	Place A	
	P(extinct) = 0.7	P(not extinct) = 0.3
Place B		
P(ext.) = 0.6	joint = 0.420	joint = 0.180
P(not) = 0.4	joint = 0.280	joint = 0.120

Note that the sum of all probabilities is 1 (any combination is bound to occur). So, the overall chance that the rhinos of this example will go extinct is only 0.420, which is smaller than the chance at place A (0.7) or place B (0.6). This is the basis of the whole idea of spreading of risk.

Just as joint probabilities can be added, so can joint conditional values. To give an example: when the chances that the rhino in Ujung Kulon will survive for 60 years is 0.852, then the chance it will go extinct is 0.148. If under the scenario 30 animals remain in Ujung Kulon and 10 will be captured, and when the chance that captive females will get 2 young equals 5%, then the chance that the rhino in captivity will survive 4 generations (60 years) is 0.002 and the chance it will not is 0.998. If the expected number under survival for Java only is 43.9 after 60 years, for the zoo 12.2, then the combined is 56.1. The conditional value is now the sum of all joint probabilities, which is the sum of (chance Java population survives x chance Zoo population survives = 0.002 x 56.1) + (chance Java population extinct x chance Zoo population survives = 0.000 x 12.2) + (chance Java population survives x chance Zoo population extinct = 0.850 x 43.9) + (chance Java population extinct x chance Zoo population extinct = 0.148 x 0) with a total sum of 37.4 "conditional animals". This means that the best available estimate of the number of Javan rhinos in 60 years time under this scenario is 37.4 adult individuals. The overall extinction chance is (chance Java population extinct x chance Zoo population extinct = 14.8%). The same can be done with the genetic variance data from Table 1.

The outcome of 17 different scenarios are shown; these are combinations of removing 0, 2, 5, 10 or 20 animals from Ujung Kulon, and moving them to a zoo (or captive breeding place) or to a nature reserve in, for example, Sumatra (Way Kambas). The zoo option has two scenarios: one with a 5% chance that a female will produce at least 2 surviving offspring and one that there is a 10% chance that this happens. The Sumatra option also has two scenarios: one that survival is inversely related to the numbers stocked and one (with improved protection) that there is a constant survival. The optimal strategy is removing 8 - 10 animals from Ujung Kulon and release them in a well protected nature reserve on Sumatra. The worst strategy is removing 20 animals into a captive stock (a zoo); the zoo scenario is always worse than no capture what-so-ever.

There is some criticism possible regarding the whole idea of genetic variability in a species like the Javan rhino. It is very well possible that in this species there is no genetic variability at all (compare cheetah) or very little variability left (compare Pere David deer). If this is true, then we can still chose the best strategy by optimizing the chance of survival and the conditional number simultaneously, as is shown in Figure 2. The conclusion is the same: the optimal strategy is removing 8 - 10 animals from Ujung Kulon and release them in a well protected nature reserve on Sumatra. The worst strategy is removing 20 animals into a captive stock (a zoo); the zoo scenario is always worse than no capture what-so-ever.

CONCLUSION

The proposal to capture a number of Javan rhino from Ujung Kulon can only be justified in terms of increased survival chances for the species, increased numbers, and halting of the loss of genetic variability. Commercial or educational justifications are irrelevant in the situation where a species is severely reduced in numbers.

A plan to capture such rare animals should have been underbuild by providing data to chose the optimal strategy within the terms of justification: increased survival, increased numbers, and reduced risk of extinction. If these calculations are not shown, then PHPA, IUCN, or WWF should not agree with any plan to seriously threaten a number of individuals with death or injury during a capture plan.

In this paper I have made a series of calculations regarding 17 different scenarios (no capture, capture of 2, 5, 10 or 20 animals; release in captive stock, release in a well-protected nature reserve on Sumatra).

The optimal strategy is to remove 8 - 10 animals from Ujung Kulon and to release them in a well protected nature reserve on Sumatra. The worst strategy is removing 20 animals into a captive stock (a zoo); the captive stock scenario is always worse than no capture what-so-ever.

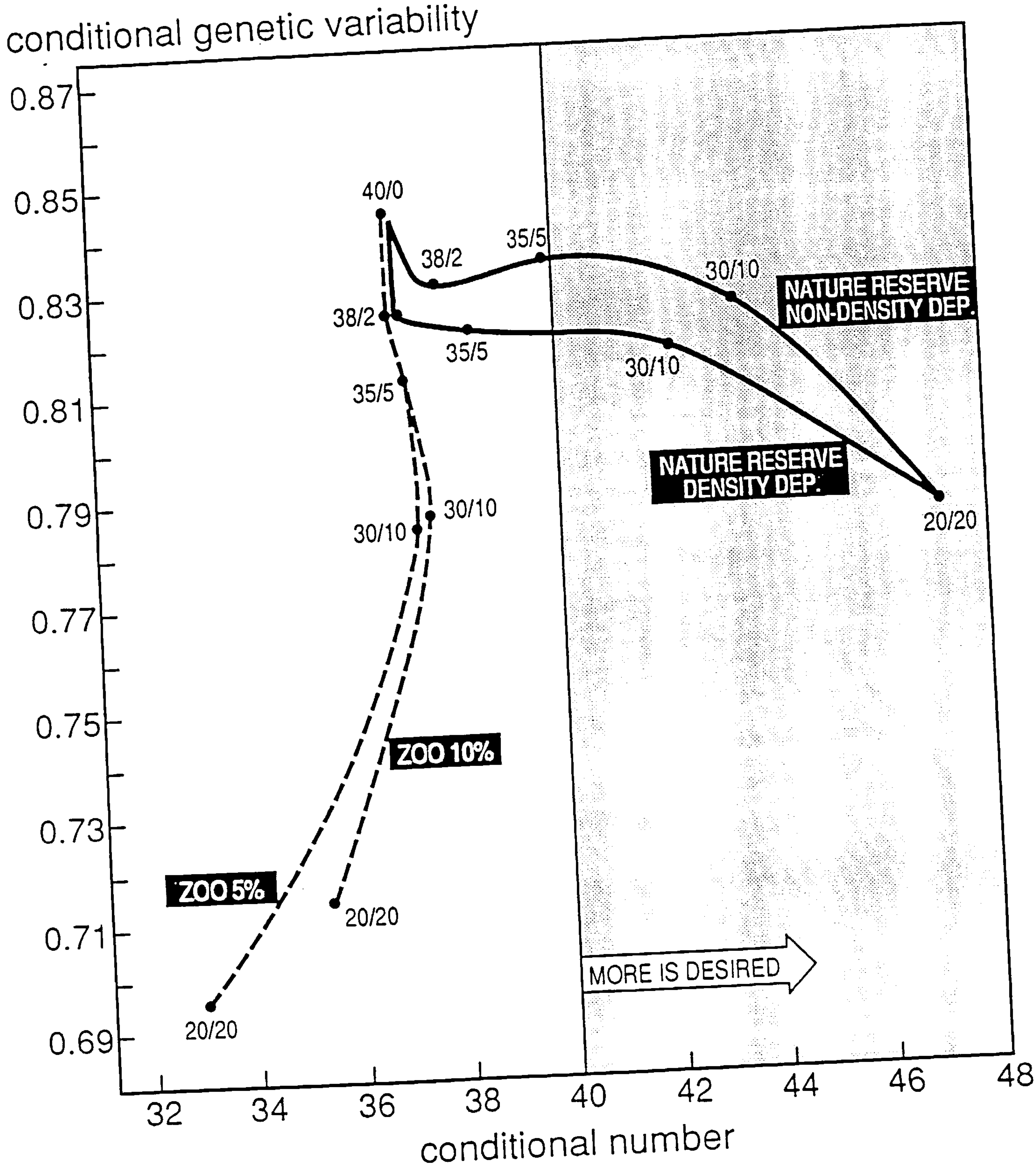
This means that when PHPA concludes that animals could be captured from Ujung Kulon, PHPA first has to prepare a well-protected large site on Sumatra - properly fenced and guarded, and with the proper vegetation - before the animals can be captured. The site should be at least large enough for allowing the new established population to grow to 20 or 30 animals, thus it should be approximately 12.000 to 18.000 hectares (needing a fence of approximately 45 km to 55 km). The animals should be released immediately after transport, and not be held in captive stock for breeding, as this diminishes the chance that they will breed and survive.

Number remaining in Ujung Kulon	Number captured	transported to / kept in: nature reserve - with normal protection	nature reserve - with extra protection	captive stock - with 5% chance 2 or more young per female	captive stock - with 10% chance 2 or more young per female
40	0	N_c = 36.9	N_c = 36.9	N_c = 36.9	N_c = 36.9
		risk = 11.3%	risk = 11.3%	risk = 11.3%	risk = 11.3%
38	2	N_c = 37.0	N_c = 37.8	N_c = 36.9	N_c = 36.9
		risk = 11.9%	risk = 6.7%	risk = 11.3%	risk = 11.3%
35	5	N_c = 38.4	N_c = 39.8	N_c = 37.1	N_c = 37.1
		risk = 9.8%	risk = 6.5%	risk = 12.8%	risk = 12.8%
30	10	N_c = 42.1	N_c = 43.4	N_c = 37.4	N_c = 37.6
		risk = 9.0%	risk = 7.5%	risk = 14.8%	risk = 14.5%
20	20	N_c = 47.1	N_c = 47.1	N_c = 33.0	N_c = 35.4
		risk = 10.8%	risk = 10.8%	risk = 21.1%	risk = 19.0%

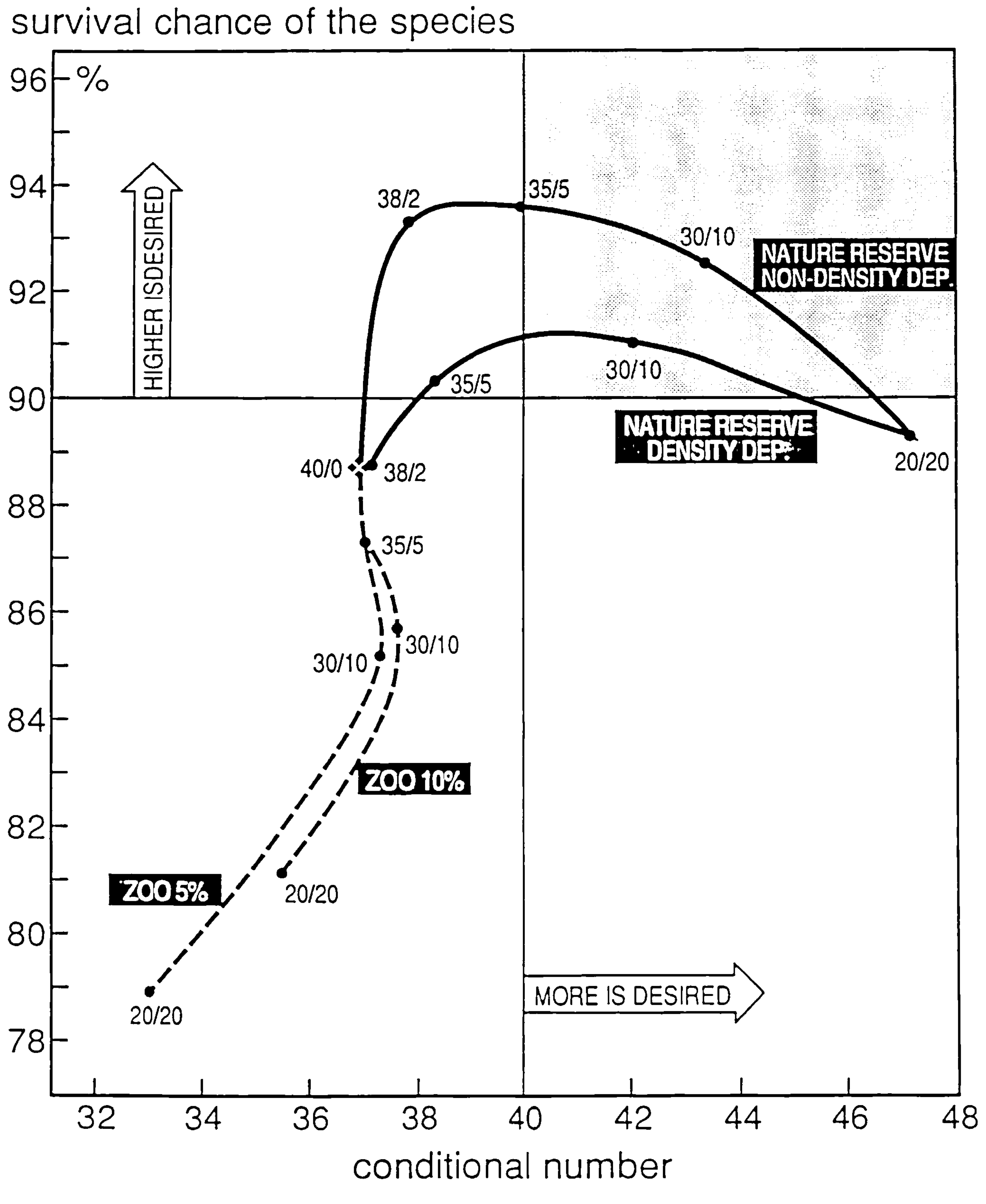
Table 7. Different scenarios with regards of number caught in Ujung Kulon and translocated to a nature reserve (for example, Way Kambas, Sumatra) or into a zoo or captive stock; both localities with two different set of assumptions. N_c means the conditional number of rhinos after 4 generations, and risk stands for the chance of extinction of all Javan rhinos (both in Ujung Kulon and elsewhere). Calculations have been made for adult rhinos only; see further the text. The species has the lowest chance of extinction and the highest expected numbers with the nature reserve scenario when about 10 adults (maximally - see the figures) are caught and released in the wild in a "new" reserve.

Number remaining in Ujung Kulon	Number captured	transported to / kept in nature reserve - with normal protection	nature reserve - with extra protection	captive stock - with 5% chance 2 or more young per female	captive stock - with 10% chance 2 or more young per female
40	0	0.844	0.844	0.844	0.844
38	2	0.825	0.830	0.825	0.825
35	5	0.822	0.834	0.812	0.812
30	10	0.817	0.825	0.783	0.785
20	20	0.786	0.786	0.695	0.714

Table 8. The conditional genetic variance after 4 generations in Javan rhino (whole world population) under different scenarios with regar of number caught in Ujung Kulon and translocated to a nature reserve (for example, Way Kambas) or into a zoo or captive stock; both localities with two different sets of assumptions. The conditional genetic variance concept is explained in the text: it is the sum of the products of chances that a specific combination will occur and the genetic variance which belongs to the positive outcome of that chance. From a genetic perspective it is <u>not</u> favourable to fragment the population.



40/0 = 40 remaining in Ujung Kulon
0 captured



40/0 = 40 remaining in Ujung Kulon
0 captured