WHAT WILL IT TAKE TO SAVE THE RHINO?

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1. INTRODUCTION

The question above may be rhetorical, for the answer may simply depend on the further question "What do you mean by 'save'?". Most people, or certainly conservationists, would feel that the world should continue to have rhinos in their wild habitats, with some in captivity as backup in some unspecified sense, and for public education and recreation. The number of conservation options for doing so is limited (Table 1). This table defines ex-and in-situ for this paper. 'Sanctuary' is used to describe any relatively small area in which rhinos are capable of closer protection and observation than in the true wild. While some small, well-protected national parks or reserves approach this standard, a sanctuary usually has barriers or fencing along all or some of the perimeter to prevent rhinos from wandering out, or other species from gaining entry. Ex-situ sanctuaries are the least used approach, typified by the free-ranging black rhinos in Texas.

The balance between these different conservation options will be largely determined by their relative strengths and weaknesses in meeting the objectives set by the organization responsible for the wild rhinos of a country. This will usually be the national wildlife management authority. Objectives increasingly have more sophisticated theoretical bases in the definition of minimum numbers and their distribution between sub-populations, analysis of threats to continued survival and the costs of preventing them, genetic considerations, carrying capacity and so on. However, any theoretical basis must be tempered by what is possible, feasible or realistic within all the restrictions and limits of the real world. Value judgements then still have to be employed in making decisions in pursuit of an overall set of objectives.

Thus, to answer the question, this overview attempts to itemise the factors which will shape a balanced conservation strategy for rhino species. It does not specify minimum requirements or conditions for any real or imaginary rhino species, for these will depend on each species' circumstances. On the other hand, it does use comparative information and experiences from all rhino species with an eye on the conservation needs of the Javan and Sumatran rhinos because these species' cases are so topical and urgent.

2. HISTORICAL TRENDS AND STATUS

Other papers describe in detail the rhino species' status in both the wild and captivity. The spectacular declines in numbers shown by each species over the last decades or several centuries are invariably due to loss of habitat or hunting for the horn, whose high value over a very long period of time is well known (Bradley-Martin, this volume). While the timing and extent of persecution for horn and conversion of habitat by humans may differ between continents and species, the actual processes seem very similar between all five species.

The five species/sub-species (Table 2) currently show a very wide range of total numbers, remaining range areas and densities. The black's low density reflects the huge offtake within human memory with large areas of known suitable habitat remaining. The Indian rhino lives at the highest density, but has a small total range. Its prospects for increase are likely to depend on expansion into new areas or parts of its historical range. Although the Sumatran occurs at 34 sites and the Javan rhino at only two, the similarity in area occupied by one animal of each species might indicate that, while range areas are much reduced, densities remain close to natural, undisturbed levels, or by coincidence both have been reduced to similar densities.

The implications of each species' situation and the urgency for effective conservation action is highlighted by using the species' data in an assessment of extinction risk (Table 3). The prognosis is based on the species numbers and distribution meeting or not meeting certain minimum criteria (Mace and Lande, 1990; Foose, this volume). While this approach does not begin to offer solutions to the rhino species' predicaments, nor does it suggest priorities, it states clearly the urgency for devising action to reduce extinction risks.

Management interventions must be based on sound information on species biology and on inter-species comparisons (Table 4). Two species are grazers in open or semi-closed habitats. The black occupies a very wide range of habitats, and the two Far Eastern species are forest browsers. This table is illustrative rather than comprehensive.

3. DEVELOPMENT OF A RHINO CONSERVATION STRATEGY

Ideally, a rhino species should be managed across its entire range within a single strategy. However, the likelihood of this happening will be approximately inversely proportional to the number of countries involved. Table 5 shows one possible approach to strategy development, appropriate for conservation of a species either across its multi-national range, at a regional level or within a single country. Development proceeds through stages:

3.1. Objective of strategy

The strategy must start by clear definition of its objective. This will be the situation which, if attained, will allow the species to be considered 'saved' by virtue of having reduced the probability of extinction to some more acceptable level.

3.2. Assessment

The first task is to assess the species' status and its threats. Strategic decisions on management can only be taken on the basis of as complete information on the species as possible. Despite much research, gaps in knowledge persist (Table 4). The gaps are greatest for the two species of greatest concern, the Javan and Sumatran, and this partly reflects the problems of seeing animals and collecting data in their forests. Information on group composition, stability and mating system should influence captive management for breeding, and it would appear that although each species could be simplistically called solitary, this would overlook considerable variation and subtlety in mating systems. Work in captivity has shown significant inter-specific differences in reproductive physiology (various papers, this volume), indicating that captive management based on cross-species experience may not be adequate.

Comparable information on the status of captive individuals must be collated for they are likely to be part of the conservation strategy. Where sub-species occur, the provenance of captive animals is important. Accumulation of accurate data, and keeping them updated, is obviously made easier by the existence of international studbooks, regional Species Survival Programs etc.

3.3 Analysis

Conservation biology theory

In this stage information from the assessment phase is used to analyse the various major conservation options (Table 1) within in-situ and ex-situ conservation. The principles of conservation biology for the Asian rhinos have been clearly enunciated (Khan, 1989). Models using rhino data prescribe, amongst other in-situ conservation activities, objectives for the minimum number and size of wild populations, as well as for secure captive populations of 150 animals of each species. A short-term (150 years or 10 rhino generations) viable population is deemed to have to number at least 100 rhinos from 25 founders, with an effective population of 50% of the total number. More detailed recommendations followed a Population Viability Analysis for the Javan rhino (Captive Breeding Specialist Group, 1989).

While the Minimum Viable Population concept has added a much-needed theoretical basis to the management of small populations, it should be seen as an analytical tool rather than as an end in itself. It can identify objectives and priorities under the assumptions and values of the population models that are run, but these may not be the final conservation strategy adopted as a result of the process described here.

Central to the MVP approach to the management of small populations is the concept of genetic exchange between the various small populations which comprise a meta-population, the secure, evolutionary unit. There should be integrated genetic management including both wild and captive populations. How realistic is this for rhinos? At the moment captive populations can be genetically enriched by the removal of further individuals from the wild, provided the immigrant animals breed conventionally in captivity. Captive-bred animals can be returned to the wild, but the probability of their successfully contributing genes to a wild population is much lower than for the wild-to-captive transfer (below). Furthermore, the status of rhino reproductive technology does not offer any encouragement for inserting captive-bred genes into the wild for many years (several papers, this volume). The MVP approach requires animals to be moved about for breeding purposes as if they were chess pieces. As a perspective, no mammal species benefits yet from integrated genetic management between its wild and captive populations. In the absence of any success here, one can query whether such an unproven approach to species rescue should be promoted for rhino species on the critical list.

Many of the inputs to a PVA are probabilities, as are most of the outputs. It is acknowledged that many of the output probabilities of extinction are crude. Their main value lies in assessing the relative importance of factors putting a population at risk of extinction, and of the relative effectiveness of alternate management actions (Lacy, 1989). Conclusions based on probabilities have their limitations. It also shows how the Javan rhino PVA came to conclusions about the desirability of some removals from the only wild population, while an alternate study based on extinction probability due to human activity over the last 100 years came to an opposite conclusion (Prins, 1991). Similarly, decision analysis to recommend strategies for the Sumatran rhino (Maguire, Seal and Brussard, 1987) requires realistic probabilities for, for example, losses at capture, during transport, the probability of successful captive breeding over specified periods of time, and of threats to natural habitat.

Protection in the wild

A country's assessment of its management strategy for rhino will include an analysis of status, threat and trend in its population. Basically, if the country decides to retain rhino and to invest in their conservation at any level other than that of ecosystem protection, the short-term objective must be a minimum population of 100-150 animals.

Within this target, decisions must be made on whether to leave all animals in the wild, irrespective of whether they are scattered and genetically not contributing, or to concentrate them at free-range or into sanctuaries. Budget ceilings and multiple demands on conservation resources encourage formulation of a strategy, even if its conclusion is to do nothing, or to remove all individuals from the wild. Apart from differing costs, management solutions will be influenced by the prevailing laws over ownership or proprietary rights to rhinos and whether they occur on government or private land.

Any assessment of trend in rhino populations must consider the state and likely future of the horn trade. The cost of protecting rhinos will partly depend on the level of challenge for illegal offtake. The latter will be crudely proportional to the value of rhino horn. Government budgets are not elastic nor able to increase greatly from year-to-year in the face of mounting challenges. Thus, a low horn price internationally and low protection costs might result in greater net return to the country, and would certainly assist states with recovering populations which can afford no offtake.

Management and breeding in captivity

Despite generally great increases in the proportion of zoo-bred rhinos now in integrated captive breeding programmes, further animals are still required from the wild. New rhinos are needed in captivity either for demographic reasons (the establishment or enlarging of captive groups) and/or for genetic diversification, or for improving the representation of sub-species.

It is common-sense that animals should be taken from the wild when their taxon still numbers 1000 rather than 50 in the wild. At the earlier stage, there is greater opportunity for selection on many criteria, greater genetic representativeness is likely by drawing the same number from the larger pool, and the decision to remove is technically and aesthetically easier. Thus, Zimbabwe's intention to allow 40 *D.b.minor* into captivity outside the country is wise when this represents only 2% of the country's estimated total population (Martin, this volume).

However, it is ironic that there are no guidelines for the removal of endangered species from the wild, as opposed to those recommending the start of captive breeding. This is in marked contrast to those referring to the return of animals to the wild through re-introduction. The cardinal rule here is that no re-introduction should jeopardise the security of the source population, which will often be a captive population.

Removal from the wild should be subject to the same constraint. The Javan rhino's present situation resulted in the proposal that, from the remaining 52-60 individuals in Indonesia, 18-26 should be removed for captive breeding (Captive Breeding Specialist Group, 1989). The basis for the removal was the high vulnerability of the 52-60 to extinction because of their low numbers. Presumably the remaining 35 in the wild would have been even more susceptible to extinction? This proposed course assumes that the probability of catching the animals, breeding them successfully in captivity and then returning at least an equivalent number to the wild was greater than the probability of them surviving in Udjong Kulon from the current 52-60 or from the reduced level of 35. There might be more prudent solutions based on greater knowledge of the wild population and with less detriment to it.

As a start, it would seem that removal of rare rhino from the wild should be subject to conditions such as:

1. The wild population should not be further endangered, unless any sub-population is doomed due to extrinsic factors such as impending habitat destruction, or unless its total is below some threshold (less than 10 individuals?), in which case all should be removed provided their removal will not provoke further adverse consequences at the ecosystem level (below).

2. The species' biology in the wild is well enough known to be able to prescribe, before capture and removal, a surmised optimal management regime in captivity for the animals' welfare and swift breeding.

How do rhino fare and breed in captivity? One measure is to compare the net rate of annual increase in the wild and captivity (Table 6). Assuming that the female of any rhino species can have a calf every two years, the maximum rate of annual increase would then be 11%. The black, both white sub-species and the Indian have been known to reach or approach these rates in the wild. Lower rates may be attributable to predation of calves, depression in breeding due to live removal regimes and year-to-year variation in ecological conditions. Rates in captivity are far lower for each species, even if acknowledging that some rates may be lowered through the demands of genetic management. However, the earlier figures for the black rhinos suggest that zoos were barely able to keep populations even at steady numbers. Although data from the Sumatran and Javan rhinos are poor, they do suggest that any rhino species under appropriate conditions in the wild or in sanctuaries (eg. Brett, this volume, for black) can increase at 6% per year. This has not been equalled in captivity for any species.

There are probably many factors, behavioural and physiological, behind the lower rates in captivity. Social factors have been implicated for the white rhinos: many were kept as pairs which had been together since young. Once these non-breeding pairs were broken, and some competition between males allowed, the same individuals bred. This situation was a better mimic of the wild one. With only the scantiest information on wild breeding for the Sumatran and Javan, how will they be managed for reproduction in captivity? Although solitary, this does not guarantee breeding as soon as a male and female are brought together. The optimal solution may include keeping all the initial captive animals at one location in a series of inter-connected paddocks, allowing periodic interactions between otherwise solitary-living individuals. In comparison, the northern white rhino in Garamba national park live at very low density yet they meet up in small, temporary high-quality habitat patches. Dung and urine deposits, sounds and smells may all allow individuals to be in communication even if they are physically out of sight (Smith, this volume).

Captive black rhinos in particular show health problems. Haemolytic anaemia of unknown origin affects animals and the viability of their calves (Miller, this volume). Further health problems in captivity may be due to inadequate Vitamin E in zoo diets compared to wild forage plants from both Zimbabwe and Kenya (Dierenfeld, Waweru, du Toit and Brett, 1990). Captive animals, but most frequently black rhinos, may exhibit nasal and skin ulcers, for which no causal agent has been isolated, which then progress to bacterial septicaemia, (Munson, this volume). Black females also frequently display inconsistent oestrus behaviour in captivity.

Information is poor or scattered, but the impression is that the correct social environment is the key to successful breeding of the white and Indian. Breeding requires individual compatibility in a pair of blacks, but adequate nutrition and health may be more critical to success. As a browsing species with diverse diets in the wild, the black may have more complex requirements for minor dietary components, in contrast to the more robust grazing species. As both Sumatran and Javan rhinos are also browsers, one may expect health problems in captivity, and delayed or slow reproduction after arrival from the wild. No Sumatran rhino calf has been conceived and born yet to any of those captured 1984-90. Many other large mammals which are ecological specialists, such as the giant panda, cheetah, lowland gorilla, did not breed successfully (including raising their own young) until after many years in captivity.

This situation, and the value placed on rhino conservation by the zoo community, is a great stimulus to research on rhino health, disease and reproductive technology. The sheer size and intractability of individual rhino creates problems for the latter. The state of knowledge, as indicated by other papers in this volume, shows that understanding of rhino reproduction is elementary compared to that of their relatives, the equids. Only when the physiological and physical bases of reproduction are understood can real progress be made towards manipulation of the process in pursuit of wider conservation goals. These will obviously include ova retrieval and transfer, both intra-and inter-specifically, gamete transport for in-vitro fertilisation and artificial insemination of captive animals, and ultimately embryo transfer. These gains will reduce the cost and improve genetic management in captive populations. Much further research will be necessary to use these techniques interactively with wild populations, a key principle behind integrated management of small and endangered populations (above).

Prospects for re-introduction

Re-introduction is the frequently-stated, final objective of the conservation prescription "removal from the wild - captive breeding - re-introduction to the wild". The idea of returning animals to the wild has a romantic and self-serving ring to it, as it assumes that a returned animal will inevitably have a better life than in captivity, and that by doing this for some individuals, man atones for the harm he may have done the species on a much larger scale. While acknowledging that returning animals to the wild may begin only many years after the start of a rhino conservation strategy, its value and scope should be assessed at the outset to ensure that including re-introduction is not a glib and cynical rationalisation for justifying taking animals into captivity on a one-way journey.

Re-introduction is used here to describe the release of captive-bred individuals. Translocation is the moving of animals from one wild site to another. Release from a sanctuary, whether of animals born there or in the wild before transfer to a sanctuary, is more similar to translocation than re-introduction. Existing or proposed rhino conservation plans envisage rhinos being released both to start new populations and also to re-inforce remnant wild ones.

Protocols exist and are constantly being refined as an approach to planning and implementing a re-introduction. These are needed because a re-introduction is a complex and multi-disciplinary exercise (Table 7), which will be fraught with uncertainties as implementation begins. Re-introductions are, inevitably, controlled risk-taking, requiring adaptive management as events -predicted or not- occur. Stringent feasibility studies and project design are needed to reduce the risks of failure and to provide answers to "what if" scenarios. For example, if all the first released animals disappear, will or can the captive population provide replacements? This may depend on (i) the demographic security of the source population, and (ii) whether the causes of loss are known and can be avoided next time through modified techniques.

The risks associated with re-introduction include the chance of bringing exotic disease with the animals. This can be a particular risk when captive-bred animals are to re-inforce wild conspecifics. On the other hand, the released animals may be disadvantaged by being immunologically naive in the face of wild diseases and parasites which present no challenge to a healthy individual born in the wild. Released animals must not cause any genetic disruption to the wild population, but there is little information on the risk of outbreeding depression. Re-introduction must also be acceptable to the people in or around the release area. The return of medium or large carnivores is regarded with particular suspicion and prejudice, and re-introduction managers must be able to demonstrate that their returned animals cannot have been responsible for coincidental, mysterious outbreaks of disease in livestock.

As re-introduction is a major element in rhino conservation plans, some basic questions should be addressed at the design stage. These would include: when, how and who decides that conditions are appropriate for re-introduction to begin? Who decides how many and which captive-bred animals will be provided? Who will pay for re-introduction -the rhino's home country or its breeders?

Concerning rhino re-introductions, there are two fundamental aspects

1. Is it technically possible to establish new populations or re-inforce others with a significant chance of reducing extinction risk? Species which are re-introducible share certain characteristics, which are shown in Table 8 with an evaluation of the Sumatran or Javan rhino alongside. These two species present difficult prospects because they are ecological specialists in a structurally complex habitat with very high biodiversity. Diet development alone will be difficult for a released, captive-bred adult rhino. Analogous to the problems faced by black rhinos in ex-situ sanctuaries, a captive-bred rhino may never develop a diet in the wild through which it obtains adequate nourishment and avoids forest plants with toxic secondary compounds. Such an animal is unlikely ever to have as adequate or diverse a diet as a wild-born animal. This may put the released animal at a competitive disadvantage and reduce its prospects of breeding, thereby negating many benefits of genetic management in captivity.

The solitary habit of the two species helps in that it is easy to create natural social groups for release, a general pre-requisite for re-introduction. However, monitoring released animals, again essential, will be more difficult and expensive because of being single, and living at low density in very thick forest.

The Golden Lion Tamarin is an ecological specialist, yet it has been successfully re-introduced (Kleiman et al., 1986). Compared to the rhino, however, its small size, ease of capture and handling allowing interventionist management in the wild, and the scope for pre-and post-release training for life in the wild promote success. More similarly to the rhino case, many endangered birds have low reproductive rates, specialised ecological requirements and solitary social groups (Fyfe, 1978). This confers poor re-introduction prospects compared to many of the bird species which have been successfully restored.

2. Can a re-introduction plan achieve results within a reasonable period of time? The availability of animals for release will depend on the numbers available from captivity. Assume no animals are available until the first captive population meets the minimum goal for short term viability (Table 9); assume only an average 2% annual increase in the species due to delayed breeding on entering captivity and current, actual rates in captivity (Table 6); then this first captive population will not reach its target size of 100 individuals for 70 years. Much may have happened to wild habitats over this period: the Population Viability Analysis for the Javan rhino (CBSG, 1989) concluded the present population had a 80-90% chance of surviving 100 years, but with declining size, and with only a few individuals remaining after 200 years. For simulated populations, the average time to extinction was always around 85 years.

It is barely worthwhile trying to estimate the cost of re-introduction under hypothetical conditions. It will be influenced by factors such as: the type and intensity of management required, the number of animals and location of the release site, the facilities needed there, the size of the release area and its security requirements, post-release monitoring, and transport costs into the release site. Many of the costs of release and monitoring will be similar to those incurred in pre-capture reconnaissance, capture and transport to the captive breeding site. If this is the case, a figure per rhino of $150,000 may be realistic, but the cost will be spread over several years. Depending on the precise objectives of the re-introduction, project duration will cover several years for animals such as rhinos. Management costs will be high to ensure the survival of immigrant females in the face of an array of novel selective pressures until they breed and their calves can grow up learning to exploit the wild environment through their critical ages. Despite present imprecision, it is fair to state that re-introduction on a significant scale will be complex, require several to many years, and will be expensive, with difficult technical aspects. Under these circumstances, it is clear that thought should be given to re-introduction even as removal for captive breeding is being planned, if return to the wild is an objective. This has, at least, been started for the Javan rhino through development of the Asian Rhino Specialist Group's Action Plan into a series of specific recommendations for Indonesia (Anon, 1989).

There is much experience with translocations of black and white rhino (eg. Booth, Jones & Morris, 1984; Hillman, 1982), and the Indian has been moved to establish new populations (eg. Sale & Singh, 1987). There seem to be two main problems. The first is the habit of individuals from these three species wandering on release. The preferred approach is now for released animals to develop a fidelity to their release site through confinement there after arrival, or the release areas should be fenced. Second, fighting between established animals and newly-released individuals may be severe, damaging and even fatal. This has been recorded in the black rhino when adult males, immature males or females have been released into sanctuaries. On the other hand, where sanctuary populations have been largely created by release, rather than breeding, a small number of animals may fill the area so that it is at "social carrying capacity", which may be less than the estimated ecological carrying capacity. This may be a function of territoriality: male Indian rhino are very territorial (Dinerstein, in press), so that newly released animals can find living space outside the high-density areas. The black, Javan and Sumatran rhinos are less territorial but, as they range over larger areas, all habitat space is used, which results in aggression and intolerance towards newcomers. Such aspects clearly complicate management of rhinos in enclosed sanctuaries through addition, and if, a sanctuary's area cannot be increased to accommodate further animals, full stocking may have to rely on natural increase from founders introduced over a short period of time. As adding more animals to an existing small re-established population soon becomes re-inforcement, social instability may be a considerable problem in rhino re-introduction. This will also mean that genetic management is only feasible through removal, rather than by addition.

It is likely that there is a considerable body of experience of rhino translocation and population management waiting to be collated for the benefit of re-introductions. There is also the feeling that the grazing white and Indian rhinos are less aggressive and easier to establish.

In conclusion, rhino return to the wild should be considered during the planning stages of the overall conservation strategy, even if it seems a far-off activity. Re-introduction of forest species may be difficult, and this should add a new set of probabilities to those of the scenario of removal from the wild -captive breeding -re-introduction.

4. SHAPING THE STRATEGY

4.1 Conservation needs, costs and cost-benefit analyses

The first steps in development of the rhino conservation strategy were an assessment of status and trends, followed by analysis of the various conservation options and theoretical desiderata. Identification of potential solutions does not result directly in identification of the optimal solution. This requires consideration of costs, cost-benefits of alternatives, the trade-offs and interactions between different conservation options, and the influence of other factors. Only some of these can be discussed here.

Very little information on the costs of, or amounts spent on, conservation in Asia is available compared to from Africa. Baseline estimates from Africa are that effective protection of a national park required expenditure of $200 per sq.km per year in 1981 (Bell & Clarke, 1984). The cost of preventing the black rhino population of Luangwa Valley from decreasing was $230 per sq. km per year (Leader-Williams & Albon, 1988).

These area-based costs translate into high costs per rhino, if all the costs of ecosystem protection are loaded on to one key species. But, live rhinos are very valuable: private landowners in South Africa have recently paid $64,500-176,000 per black rhino for restocking farms. A white rhino could be bought for $20,000 in 1990. Any return from these animals is from tourism, and also from trophy hunting for the white.

Zoos are also prepared to pay for rhinos for captive schemes. Thus, members of the Sumatran Rhino Trust of the AAZPA will pay Indonesia $60,000 for each of up to 10 animals surviving up to one year in the USA, in addition to capture and transport costs, with further obligations for general conservation support, technical assistance and training. Zimbabwe is preparing to allow removal of up to 40 black rhinos to the USA and Australia in return for two helicopters, for capture and anti-poaching work, and their support over 7 years, with all capture and transport costs. This roughly values each rhino at $62,000.

Using base figures from various rhino species, it is possible to estimate the comparative costs of conserving rhinos through captive breeding, in a sanctuary and in the wild. The objective for the first scenario is set as a population of 100 animals from 25 founders (Table 9), and it is assumed that no animals will be available for re-introduction until 100 is reached. The capital costs of establishing the 25 founders are estimated in Table 10 as $4,470,000 . Table 11 shows an estimate of recurrent maintenance costs as more than $370,000 per head. If the captive population increases at an average of 2% per annum, then recurrent costs will have to borne for an expanding number of rhinos for at least 70 years until they number 100.

Protection in the wild may cost $230 per sq.km per year (Table 12), but this was in the face of an extremely high challenge to the rhino population. The rate of $55 for Garamba NP is adequate under present conditions where the challenge is low, and the main problems to effective protection have been removed through externally-funded assistance for overall park rehabilitation. The Tsavo NP rate of $27 per sq.km per year currently prevents all elephant and rhino poaching, and deters illegal entry.

The cost of protecting a viable wild population can be calculated thus: assume N_e/N in the wild is 0.35 (cf. 0.5 in captivity) so that the minimum number of animals for short-term viability is 142 (cf. 100 in captivity); assume a density of 2 sq.km per rhino, and a protection cost of $200 per sq.km. The recurrent cost of protecting this population will be $56,400 per year, or $417 per rhino.

The Ngulia rhino sanctuary is embedded within Tsavo NP (Table 12). Because it is fenced and has high security, it costs far more per sq. km than the park as a whole. Because it has recently been extended, it is understocked with rhino. Hence the cost per rhino annually is high, but at the estimated carrying capacity the cost will drop to $700 per rhino per year, rather less than twice that of rhino in the wild without extra protection.

On a cost basis alone, the ex-situ captive breeding option is far the most expensive, both because of the capital costs of the rhinos, and then because of the higher maintenance costs. The cost of reaching a specified number of rhinos in captivity will also be higher because of the lower rates of increase (above). There is a further factor: costs in captivity increase in direct proportion to the number of animals. In both the wild and a sanctuary, the costs of protection and management relate more to unit area, so that as rhino numbers increase, the cost per rhino drops and the overall cost remains constant.

Any cost-benefit analysis must look at other factors. All wild rhinos live in an ecosystem, and if the rhino is effectively protected in-situ, then a myriad other species will also benefit. In global terms, protection of flagship species, such as all the rhino species, assists biodiversity maintenance, and this may be especially important in Asian forests. For example, three reserves in Sumatra containing the Sumatran rhino and covering 26,000 sq.km, shelter 63-68% of Indonesia's threatened mammals (Santiapillai and MacKinnon, 1991).

Conservation assistance for the specific protection of rhinos in their habitats provides free conservation for the rest of their communities. The corollary is that if the rhino is exterminated, alternate funds may be hard to find, and pressure will mount for alternative uses of the land. This is relevant to the removal of 'doomed' groups of Sumatran rhino. Such animals are valuable for translocation or for captive breeding, but their removal may consign their forest ranges to certain clearing. This is akin to the situation of Garamba NP in Zaire, which became a World Heritage site in 1980 largely -though not entirely -because of its remnant population of northern white rhino. If the remaining 13 animals had been removed to captivity in 1983, as was proposed, no doubt the World Heritage status would have remained, but the park would not have attracted a major rehabilitation project of long duration, and it would have been unlikely to receive assistance from UNESCO worth an annual average of $50,000.

4.2 Political perceptions and realities

The world's most endangered species today are in the third world, while most captive-breeding facilities are in the west. Taking animals from the wild is a sensitive issue, and the approach to devising strategies and plans requires great care. Some of conservation biology theory's basic tenets may be counter-intuitive to those with a non-western view of conservation. Why for instance should a country understand or allow removal of some of its last remaining wild animals to broaden the genetic base of a distant captive population before at least the same number of animals have ben exchanged into the wild? The Omani beduin of the Arabian oryx re-introduction area could not believe that there was a captive population in the USA. Until they saw the first returning animals, they were convinced the project would impose a different species on them (Stanley Price, 1989).

In general, third world countries are aware of the value of their wildlife, especially if they include very rare, endangered or endemic species. This situation is due to great media attention and the exhortations of western conservationists to protect them (often without providing extra means to do so). It is not surprising then that outsiders are resented when they come to ask to remove animals for captive breeding, to the apparent benefit of the receiving country rather than the source. The intent to set up an ex-situ population may be taken as a sign that the country cannot look after its own natural resources, however compelling the need for a captive population from a western perspective.

Data above showed the value to a country of owning rhinos which it is prepared to sell. What is the optimal way to realize and apply this value? A flat payment for each rhino surviving capture, transport and a minimum period ex-situ is an incentive to good management, but it constitutes payment on results. A broader view would be that if zoos wish to obtain rhinos, they are acting with good faith and intent to help conserve the species. They should, therefore, pay for the privilege of being able to try to catch the natural heritage of a rhino country, rather than on the results. Ideally, the fee for this privilege may meet conservation needs of materials or training, but it should also ensure institutional development in the rhino country in the interests of improved wildlife management. This sort of commitment by the zoo world would help avoid suspicions of conservation imperialism through third world resources being removed for experimental use, without guaranteed certainty of any animals returning.

The IUCN Veterinary Specialist Group has developed a position on disease risks associated with translocations (including the release of captive-bred animals) because of increasingly apparent hazards and experiences. Traditionally, animals in zoos have been regarded as being in perpetual quarantine. With recent outbreaks of disease such as Ebola fever in imported primates, and African horse sickness in Spain, the movement of wild-caught individuals is likely to become increasingly restricted by national and international legislation. Use of third countries to "pass through" wild-caught animals between source and destination has also increased unease over wild animal movements internationally. The return of animals for re-introduction may also be jeopardised if their home country has import veterinary requirements which cannot be met by the captive-breeding country. This is now almost the situation for Arabian oryx destined for Oman, which received 34 oryx from the US over the years 1980-88. If such situations increase, the very rationale for captive breeding as a conservation strategy could be undermined. The US also has domestic legislation and guidelines relating to the importation of individuals of endangered species of other countries. For import permits to be issued, management of the species ex-situ must be demonstrably in support of improving conservation of the same species in-situ, except where a wild population comprises only a few remnant individuals. This should be a powerful incentive to ensuring good management and research of relevance to in-situ conservation, and to providing animals for re-introduction where relevant.

4.3 Public awareness and perceptions

Zoos increase public awareness of conservation issues as well as providing opportunities for recreation, education and research. Expensive captive-breeding programmes depend on support from the public, benefactors or local authorities.

Rhinos are charismatic large herbivores, perhaps second only to the elephant in appeal. It is understandable that zoos wish to obtain and display species which are rare or novel in captivity. But, in the case of the rhino species, is there evidence to show the added impact on the public of displaying a Sumatran rhino in a zoo which already has perhaps black, white and the Indian rhinos? So many tourists visiting the Lake Nakuru National Park in Kenya, which is a black rhino sanctuary, expressed disappointment at not seeing the rhino (which were almost exclusively using thick forest) that several white rhino, which use open grasslands, have been released as alternatives, and apparently meet tourist requirements for a rhino sighting. Analogously, the Asian elephant, which is more common in captivity than the African, has been much used to promote awareness of the plight of the latter in the wild.

Zoos may have to compromise in their desire to show the public individuals of a newly acquired rhino species if being on view is incompatible with breeding the species. To what extent will the supporting public tolerate such compromises? It is arguable that with a small number of Sumatran rhinos in the US, all should be managed at one site for maximum effort to start breeding. This would obviously leave the remaining zoos which have contributed equal shares to the cost of purchase, capture and transport without any rhino on view. This would perhaps be unacceptable, although the alternative of keeping one or two rhinos at each participating site may retard breeding.

5. THE CONSERVATION STRATEGY

The approach described here is a generic one for designing a rhino conservation strategy. It is applicable at the national and regional levels, and perhaps might be optimally used for a species over its entire range. At this last scale, where there may be many populations on which to exercise some conservation management, some priority populations will have to be identified. A process for ranking priority has been developed for both the African elephant and rhinos (Cumming, du Toit and Stuart, 1990), and in the South African black rhino conservation plan (Brooks, 1989). In deciding which are priority populations for attention, with the greatest chances of success, a range of biological and non-biological attributes are scaled. In contrast, this paper concerns the advantages and disadvantages of different types of rhino protection and management, rather than identifying priority populations *per se*.

The rhino conservation strategy formulated will depend on the questions being asked. Fundamentally, these relate to the status and prospects of the wild population and the chances for improving status through other means, which are here simplified into ex-situ captive breeding and confinement to in-situ sanctuaries. The objective of the strategy must be clearly defined, in terms of minimum numbers and distribution, and their genetic management to ensure demographic and genetic viability over a specified period. Table 13 compares the three approaches for various aspects of rhino conservation, and their costs. The rank orders show how ex-situ conservation is more expensive for establishment and maintenance of a population, and then for returning animals to the wild. The sanctuary is always more expensive than the wild.

Among the other attributes, the ex-situ population wins for internal genetic management potential, and for guaranteeing best the physical security of the animals. If these are important elements for increasing the viability of a species or population in the wild, then an ex-situ population should be a priority in the strategy. If the physical security of rhinos in-situ is not a concern, but inadequate numbers are the problem, then the wild or sanctuary solutions should be emphasised. The rate of increase is a potent management tool, for if a population has suffered a rapid and severe decline, it may lose genetic variation through genetic drift. The effect can be avoided by a quick recovery in numbers after the bottleneck. The Indian rhino in Kaziranga seems to demonstrate this (Dinerstein & McCracken, 1990). Rapid increase in numbers is a feature of the South African conservation plan, to avoid having to maintain genetic diversity through the physical movement of animals between high-density populations (Brooks, 1989).

The attributes cannot compare the absolute merits of the three conservation techniques for maximising genetic or demographic security against extinction. This is because these measures are so dependent on the number, origins, sex and age distributions of the animals involved.

The attributes are given rank positions only, rather than arbitrary relative values. With further work, values could be assigned. By combining scores, one could then see under what management it would be possible to optimize, for example, maximum ecosystem benefits with a fast rate of increase irrespective of the costs of re-introduction / translocation.

6. FUNDING

Implementation of any rhino conservation strategy will require considerable funds. Zoos are unlikely to prove major sources of field conservation support, even if provision of animals is one element of a strategy (Foose, this volume).

There are two obvious possibilities for funding. The countries with rhinos in southern and eastern Africa, northern India, Nepal and Assam already have considerable tourist industries. These are based on relatively open habitats, which attract people because of their scenery, the diversity of wildlife and its visibility. Improving the level of revenue from tourism for conservation may need radical, innovative approaches (eg. Martin, this volume).

In contrast, the Sumatran and Javan rhinos live in thick forests. Almost no short-term tourist is going to see a wild rhino of either species. However, their forests are biologically much richer than the more arid habitats of the other species. Biodiversity is currently the key to substantial funding through mechanisms such as the European Community's Lome IV round, or the World Bank-UNDP-UNEP Global Environmental Facility. Identification of the Sumatran rhino in the Global Heritage Species Program (Captive Breeding Specialist Group, 1990), for which occurrence of animals in captivity is proposed as a criterion for eligibility, might promote biodiversity funding into such areas. This might be the means to ensure protection in perpetuity for areas which can never be economically self-supporting in conventional ways, but which the world is not prepared to lose.

7. CONCLUSIONS

To save the rhino, or any species or population, requires a sound conservation strategy, whether at the national, regional or whole species range level. For each rhino species, very few states still retain wild populations, which should encourage integrated action. On the basis of this overview and the state of contemporary rhino conservation as presented in this volume, a number of conclusions and suggestions are advanced in the interests of improving the status the world's five rhino species:

1. A conservation strategy must be multi-disciplinary, comprehensive and balanced. For this reason, responsibility for producing should lie in the hands of the wildlife management authorities of the rhino-owning country or countries participating. They should ask for and expect any cooperation and inputs of technical expertise required. This should lead to a more balanced strategy than if it is the responsibility of any single interest group(s) amongst the range of relevant disciplines. This will result in a strategy which maximises options and minimizes regrets.

2. Data and experience on the behaviour and performance of captive rhinos of all species under different management regimes with respect to breeding rates and success should be collated and analysed. This could lead to improved success, and prediction of methods for species not yet or barely in captivity.

3. Guidelines should be developed for the removal of animals from the wild, with consideration of extinction risk assessment, strategies of least regret, realistic comparative probabilities, etc.

4. Comparative data on release and re-introduction techniques, results and experience require comparative analysis. This would be directed to improving translocation success and the ability to insert rhinos into established populations.

5. There should be carefully-planned and monitored releases of a few captive-bred rhinos (of genetically and demographically redundant individuals of appropriate sub-species) into wild or sanctuary populations to see if and how genetic exchange between captive and wild populations is feasible without invasive reproductive management.

6. Research on rhino reproductive biology and physiology must be promoted in an effort to close the gap between conservation biology theory and practicable management.

7. All rhino management regimes or strategies, but especially those involving captive breeding, should have clearly stated goals, with time-scales and success indicators. This would allow, at specified intervals, objective assessment of success or problems, at which points alternate regimes, methods, combinations of animals etc. would be initiated in the hope of greater success.

8. Around the world there is a plethora of national, international or advisory groups for aspects of rhino conservation and management, including the Asian Rhino Specialist Group, and African Elephant and Rhino Specialist Group, and many regional Species Survival Programs. However, there remains a need for fuller information flow in the interests of a more comparative and predictive approach to interventionist rhino management. To this end, greater exchange between Asia and Africa would seem particularly desirable.

Acknowlegements: It is a pleasure to thank Nigel Leader-Williams for his help with data and stimulating discussions, and the many people around the world who provided information, published or otherwise. Deborah Snelson and Ursula Shimechero, of the African Wildlife Foundation, assisted greatly with production of this paper.

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Table 1. OPTIONS FOR RHINO CONSERVATION EX-SITU AND IN-SITU

frozen gametes → captivity out of range → sanctuary out of range → sanctuary in range → wild

EX-SITU ——————————| |—————————— IN-SITU

Table 2. RHINO SPECIES: TOTAL NUMBERS, HABITAT AREA AND PRESENT DENSITY

Species	Total no.	Habitat sq. km	Density sq. km/rhino
N.White	28	4,900	175.0
S.White	4,719	58,481	12.3
Indian	1,724	2,533	1.5
Black	3,392	317,735	93.7
Sumatran	536	29,732	max 25.7
Javan	60-69	1,511	max 21.8

Sources:
Cumming et al. (1990)
Gakahu (1991)
Khan (1989)
Santiapillai et al. (1991)
K.H.Smith (pers. comm. 1991)

Table 3. STATUS OF RHINO SPECIES IN THE WILD

CATEGORY	Prognosis	Species or sub-species
CRITICAL:	50% probability of extinction within 5 years or 2 generations, whichever is longer	Javan N. White
ENDANGERED:	20% probability of extinction within 20 years or 10 generations, whichever is longer	Sumatran Indian Black
VULNERABLE:	10% probability of extinction within 100 years	? S. White

Categories from Mace and Lande (1990)

Table 4. SOME BASIC INFORMATION ON RHINO SPECIES BEHAVIOUR AND ECOLOGY

Species	Habitat	Diet	Group composition	Group stability	Mating systems
White	open grassland	grass	groups < 6	not stable except at good feeding sites	exclusive mating territories
Indian	marshy & open grassland	mixed	groups < 6	not stable, esp. female with subadults	? exclusive territories
Black	desert - bushland -montane forest	browse	* solitary	very low	territorial: facilitative monogamy, polygyny
Sumatran	lowland swamp forests-montane rainforest	browse	* solitary		unknown
Javan	dense lowland forest, open grass-land patches	browse	* solitary		unknown

* 'solitary' excludes all female-calf pairs, and temporary male-female associations

Table 5. DEVELOPMENT OF A RHINO CONSERVATION STRATEGY

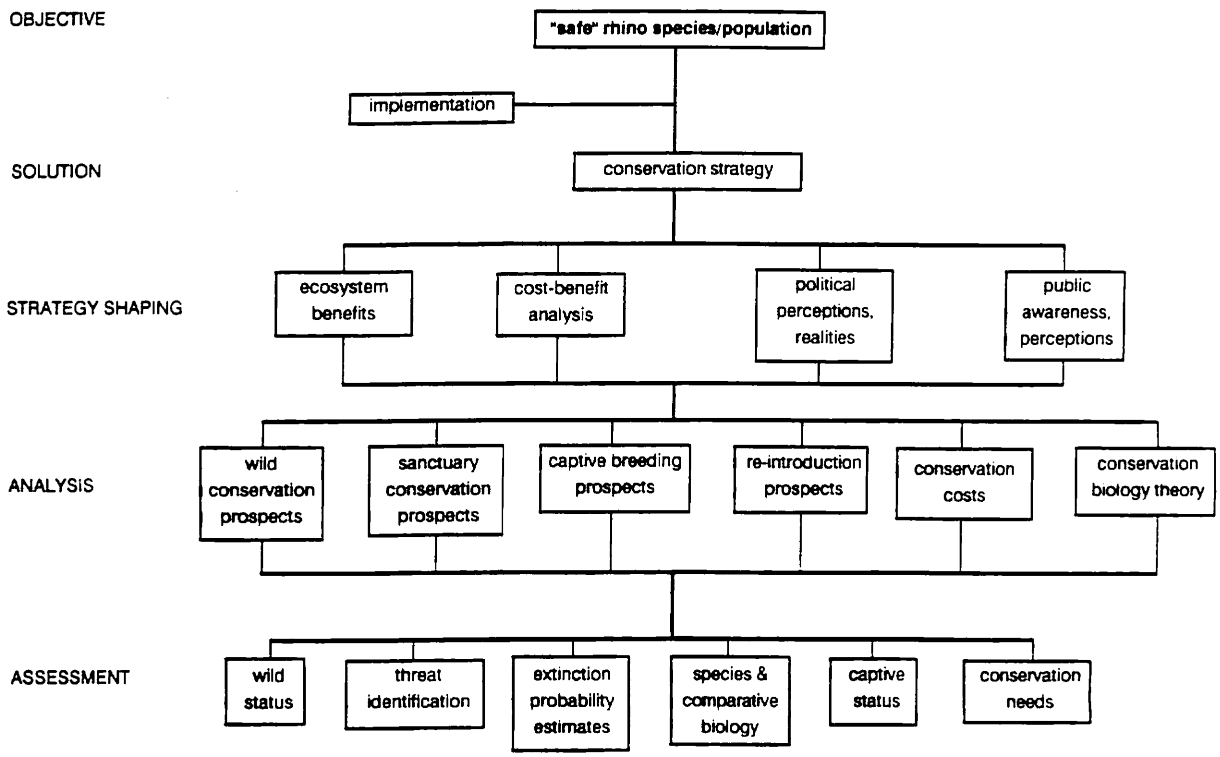

Table 6. ANNUAL RATE OF INCREASE IN RHINO SPECIES, %

		WILD		CAPTIVITY		
White	Umfolozi	7.0	(~1920-70)	* N.Amer Stbk	1-2.0%	(1988-90)
	Umfolozi	9.6	(1960-72)			
	Kruger	8.5	(1980-90)			
	Kruger	10-11.0	(1990)			
	† Garamba	14.3	(1939-63)			
	Garamba	9.7	(1984-91)			
Indian	Kaziranga	11.5	(1908-40)	N.Amer	4.5	(1989)
	Kaziranga	2.7	(1940-90)	N.Amer Stbk	< 3.5	(1972-87)
	Kaziranga	5.0	(1989)			
Black	Umfolozi	11.0	(1961-73)	IZYB	-7.0	(1969-88)
	Kruger	9.0	(1990)	IZYB	1.25	(1971-81)
	Hluhuwe	10.0	(1990)	N.Amer	2.0	(1987)
	Kenya sanctuaries	6.0	(1990)	N.Amer SSP	3.1	(1988-90)
Sumatran		?			?	
Javan	Ujung Kulon	6.2	(1967-80)		?	

* period of genetic management and reduction in size of captive population
† unreliable

Table 7. FACTORS RELEVANT TO A SUCCESSFUL RE-INTRODUCTION (Stanley Price, 1989)

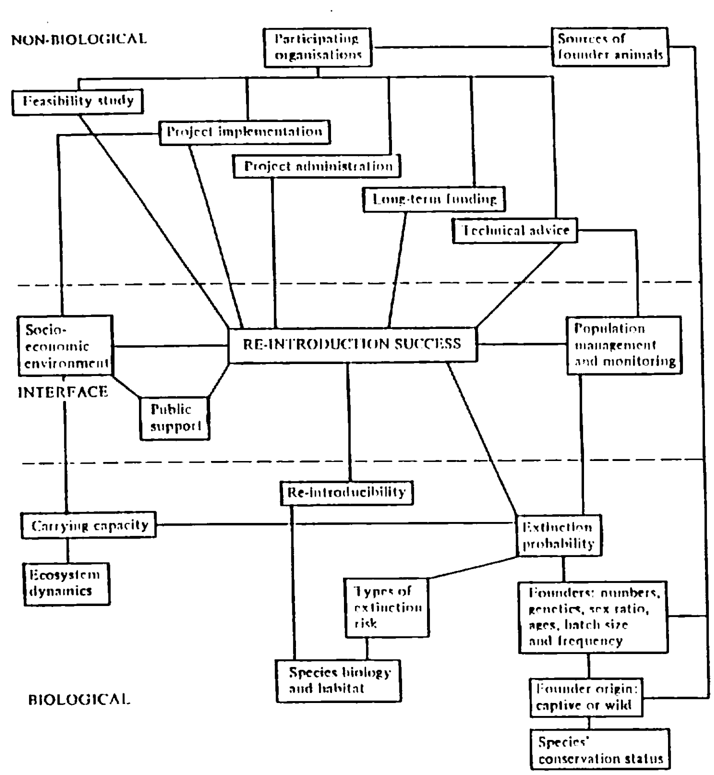

Table 8. THE JAVAN AND SUMATRAN RHINOS ASSESSED FOR RE-INTRODUCIBILITY

	Characteristics of re-introducible species	Javan or Sumatran rhino
1.	Generalists of extreme environments	No
2.	Species tolerant of habitat change or of wide range of habitat conditions	No (c.f. black rhino)
3.	Species with cohesive groups	No, but some advantages of being solitary
4.	Large animals	Yes
5.	Explorer species	No: limited ranges
6.	Scavengers	n/a
7.	Species with sanctuaries in habitats	Yes: dense forest
8.	Nocturnal species	n/a
9.	Species whose behaviour can be manipulated	? Yes: only through release site fidelity
	Easy to monitor progress?	No: - solitary - low density - thick density

Table 9. OBJECTIVES FOR CAPTIVE RHINO POPULATION FOR SHORT-TERM SURVIVAL

a. In captivity, 100 rhinos can provide genetic and demographic viability for 150 years (10 generations)

b. Ne/N in captivity can be 0.5

c. With 25 effective founders, 80% total genetic variation will be preserved after 10 generations.

Source:
Khan (1989):

Table 10. COSTS OF ESTABLISHING CAPTIVE POPULATION OF SUMATRAN RHINO

1.	25 founders delivered to zoo	
2.	Mortality rate between capture and arrival at zoos is 33% (1)	
3.	Thus, 8 extra rhino are to be caught	
4.	Assume 4 die during capture and 4 die within first year of removal from forest base camp	
5.	Fee, capture and transport costs for 25+4 rhinos @ $ 150,000 (2)	$ 4,350,000
6.	Indemnity for 4 rhinos dying during capture @ $ 5000 (3)	$ 20,000
7.	Indemnity for 4 rhinos dying in first year in zoos @ $ 25,000 (3)	$ 100,000
8.	Total cost of establishing 25 founders	$ 4,470,000

Sources:
(1) Santiapillai & MacKinnon (1991)
(2) Abdulla, Zainuddin & Suri (1989)
(3) Anon (1990)

Note:
Although data taken from agreement between SRT/AAZPA and Min. of Forestry of Indonesia, the agreement covers the transfer of a maximum of 10 rhinos to USA, rather than 25 founders.

Table 11. MAINTENANCE COSTS OF SUMATRAN RHINO IN CAPTIVITY

1.	Indian rhino in US zoo in 1984,	@ $ 8,391(1)
2.	Cost in 1990 at 10% annual increase,	@ $ 14,865
3.	No of rhinos to be maintained: 25 excluding those dying in first year	
4.	Cost of maintaining 25 rhinos per year	$ 371,625
5.	Transport costs for genetic management, per rhino per move:	$ 20-40,000

Source:
(1) Conway (1986)

Table 12. COSTS OF PROTECTING RHINOS IN AFRICA

1. Luangwa valley, Zambia:
   $ 230 /sq.km (Leader-Williams & Albon, 1988)

2. Garamba NP, Zaire, 4,900 sq. km: currently $ 55 sq. km in external assistance at current stocking: $ 9625 per rhino per year;
   at maximum past no. (1300 in 1963): $ 207 per rhino per year
   (Hillman Smith, 1990)

3. Ngulia sanctuary inside Tsavo NP Kenya
   Sanctuary: 73 sq. km
   Tsavo NP: 20,800 sq. km

Tsavo budget:	$ 27 sq. km per year
Sanctuary:	$ 700 sq. km per year
at current stocking:	$ 4650 per rhino per year
at carrying capacity:	$ 700 per rhino per year

   (R.A.Brett, pers. comm., 1991)

Table 13. RELATIVE BENEFITS OF 3 TYPES OF RHINO MANAGEMENT

	ex-situ captivity	in-situ sanctuary	in-situ wild
Cost per rhino:			
Establishment	3	2	1
Maintenance	3	2	1
Re-introduction or translocation	3	2	1
Scope for genetic management within	3	2	1
Physical security	3	2	1
Ease of transition to wild	1	2	3
Probability of successful re-introduction or translocation	1	2	3
Rate of rhino increase	1	2	3
Ecosystem benefits	1	2	3
Public awareness			
- range state	1	3	2
- zoo state	3	2	1