Received 31/8/90. This gives us a good opportunity to respond & state our preference for 'in situ' conservation.

All the world's a zoo

Captive breeding may no longer be enough to save endangered species. Is it time to start manipulating the animals left in the wild?

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Alain Compost: Bruce Coleman

Playing hard to get: the Sumatran rhino is hard to find and more difficult to catch, but an arranged marriage may be its only hope

A LITTLE over a year ago, a group of conservation biologists flew into Bogor, in Indonesia. They had gone to work out a plan to save the rarest of the world's rhinoceroses—the Javan and Sumatran rhinos. The biologists were armed, not with guns and razor wire, but with a personal computer and programs designed to work out what the chances of survival were for small populations.

The team fed information about the age, sex and distribution of rhinos into the computer, which then produced estimates of the rhino's chances under various conditions. From these estimates, the biologists designed a survival plan: the rhinos, they decided, should be reorganised into new populations, some in captivity and some in the wild, and the animals should be managed as a whole—as a "megazoo".

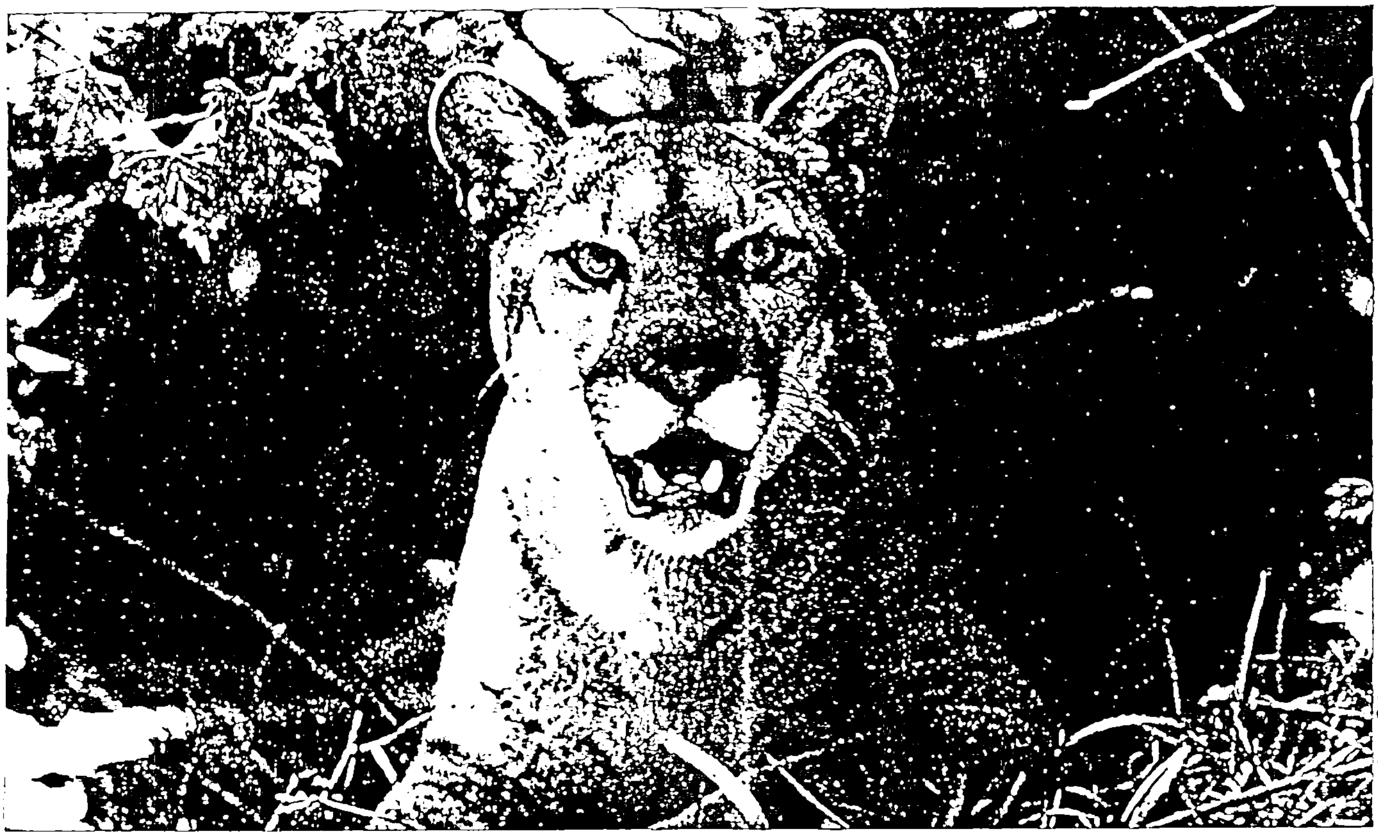
Managing animals in the wild as closely as captive populations is a controversial strategy. But as Peter Bennett, a conservation coordinator for the British Zoo Federation, points out: "The term 'megazoo' may have connotations of Victorian animal houses, but you can't avoid the fact that in 100 years' time it is likely that no animal will be able to survive in the wild without close management, because there will be no wild left."

The World Conservation Union (the IUCN) has a group of captive breeding specialists advising conservationists on issues related to captive breeding as part of the Species Survival Commission. The group coordinates international breeding programmes and provides zoos, wildlife parks and other organisations with technical assistance for managing small populations, both captive and wild. "We are moving towards the situation where there is no distinction between captive and wild," says Tom Foose, a member of the group. "Unless we exercise close management in the wild, the smaller populations are not going to survive."

The Javan rhino (*Rhinoceros sondaicus*) and the Sumatran rhino (*Dicerorhinus sumatrensis*) are typical of small populations threatened with extinction. There are fewer than 1000 Sumatran rhinos, and these live in small, isolated populations. The Javan rhino is rarer still, with a single known population of around 70 animals, based in the Ujong Kulon National Park in Java. With poaching and the continued destruction of their habitat, these populations are likely to dwindle still further.

Although guards and fences can help to slow the losses, a small population's survival does not depend entirely on the number of animals. Chance variations in other factors can also affect it. Disease or a natural disaster such as a hurricane can wipe out a small population. Unexpected failures in breeding, or a bias in sex ratios, can also alter the structure of the population. And inbreeding, or no breeding at all, accelerates the loss of genetic diversity: a gene pool can very quickly shrink to a gene puddle.

These problems are characteristic of any small isolated population, including animals living in zoos. "Zoos have been



Jeff Foott/Bruce Coleman

Centre of controversy: plans to "manage" the endangered Florida panther have upset conservation groups

confronted with the problems of managing small populations for many years, and have developed analytical techniques for minimising the risks to the survival of these small populations," says Bennett. This has led the IUCN's captive breeding group to the conclusion that it is now time to start managing shrinking wild populations as if they were in captivity. "In most cases this is not intervention, it is just good management," says Georgina Mace, of London Zoo.

Curators at zoos and wildlife parks have taken management of their animals more seriously over the past 20 years and are keen to play a leading part in conservation through captive breeding (see "Breeding by numbers", *New Scientist*, 1 September 1988). To this end, zoos around the world are developing captive breeding programmes. By splitting captive populations among several zoos around the world, the zoos maintain the genetic diversity of the species so that when surplus animals are returned to the wild, they have the wherewithal to cope with their natural environment, and add new genes to the local gene pool. This strategy also helps to prevent a single disaster from wiping out a whole species.

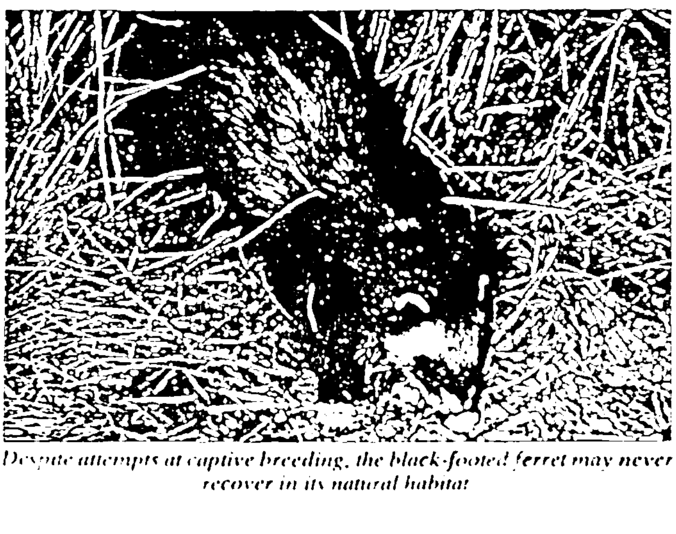
Stud books and computer databases play a central role in animal management. One of the most widely used databases is the Animal Record Keeping System (Arks), developed at Minnesota Zoo in the US, and now used by more than 300 zoos around the world. The central database holds information on the pedigrees of more than 100 000 animals in 32 countries, allowing curators to identify suitable mates for animals in their collections.

In theory, a database such as Arks should make it easy to prevent inbreeding. In practice, it is more difficult. For many species, all the zoo animals are descended from just a few animals introduced from the wild. And there is sometimes no record of the relationship between present populations and their founding fathers and mothers.

The problem of incomplete records has prompted several groups to develop programs that analyse the genetic make-up of populations and their demographic structures. These include "Sparks", the Single Population Analysis and Record Keeping System, devised by the group at Minnesota Zoo, and Gene Drop programs, which estimate the loss of genes down through the generations and calculate the ideal distribution of those genes. Zoos and parks can then set up breeding programmes to achieve that ideal distribution.

New techniques in biochemistry and genetics are beginning to fill in some of the missing information. Genetic fingerprinting, for instance, can identify an animal's parentage and the degree of genetic diversity in a particular population. Improvements in DNA analysis should lead to more accurate information.

Zoos are using these techniques to gather information



Edgar T. Jones/ARDEA

Despite attempts at captive breeding, the black-footed ferret may never recover in its natural habitat on the genetics of small captive populations. London Zoo has just fingerprinted the scimitar-horned oryx at London and Amsterdam Zoos. The tests showed that the animals in Amsterdam had a greater variety of genes than those in London. This allows the zoos to improve their breeding programme for oryx to increase the diversity of the London population.

Biologists working in the field can apply the same techniques to wild animals to work out their pedigrees. Refinements to DNA analysis mean that it is now possible to obtain a genetic fingerprint from the tiny amount of DNA in a single hair, or from the cells in urine.

In the early 1980s, conservationists and zoo biologists started to build computer models that predicted the survival of populations, based on genetic and demographic analyses. One of the first studies took place in 1983 in Yellowstone National Park in the US. Mark Schaffer, a biologist with the US Fish and Wildlife Service, calculated that the park had to have at least 50 female grizzly bears for the population to have a 95 per cent chance of survival. He called this the "minimum viable population". This method of calculation has limitations. Schaffer's model considered only the reproductive capacity of the population based on the ages of the animals. In reality, many other factors affect the viability of a group of animals.

This led Mike Gilpin and Michael Soule, of the University of California, San Diego, to suggest adding all the other interacting factors, such as variations in the environment, catastrophes and genetics, into the computer models to produce more accurate simulations. They called their technique "Population Viability Analysis".

Gilpin and Soule first tried their technique in 1986 on the endangered Concho water snake in Central Texas. Since then, other researchers have applied variations of the technique to other species, including the black, Sumatran and Javan rhinos, the red wolf, the Californian condor, the Florida panther and the Puerto Rican parrot (see Box).

Over the past 18 months, the IUCN's captive breeding group has held a number of workshops based on population viability analysis. Field biologists provide the data for the analyses from their observations of real populations of animals. The conservationists then use the results of the analyses to design "Species Survival Plans".

Collecting the essential information to produce an accurate analysis is often tricky. In the case of the Javan rhino, gathering the data to set up the computer model was particularly difficult. There are none of these rhinos in captivity and they

Out of the zoo and into the rainforest

IT DIDN'T take a computer to work out that the Puerto Rican parrot needed better management. At a workshop run by the IUCN captive breeding group in June last year, one of the participants watched a parrot eating paint from the wall of the Luquillo aviary. This prompted him to recommend more careful management at the aviary.

This simple line of reasoning contrasts with the scientific analysis on which the participants at the workshop based the rest of their recommendations. At the week-long workshop, members of the captive breeding group, along with field workers and the US Fish and Wildlife Service, applied population viability analysis programs devised by the captive breeding group to quantify the parrot's chances of survival. They then used the results to map out a Species Survival Plan.

The Puerto Rican parrot, *Amazona vittata*, is heading for extinction. In June last year it existed in the wild as a single population of 34 birds in the Luquillo Forest, part of the Caribbean National Forest on Puerto Rico. There was also a captive population in Luquillo and plans to establish another at Rio Abajo with a total of 46 birds.

At one time there may have been as many as a million Puerto Rican parrots across the island. A hurricane in 1899 may have started off the bird's decline. But, since then, disease, loss of habitat and poaching have led to a continuing fall in numbers. Over the past 20 years, the Fish and Wildlife Service has made extensive efforts to protect the wild birds, guarding the nests of each wild parrot to deter egg thieves, and transferring eggs and birds between the wild populations and the aviaries.

Despite these measures, the viability analysis did not give very encouraging results. It gave the birds a 66 per cent chance of survival over the next century, unless more drastic steps are taken to help them. The biologists at the workshop suggested a number of measures that would give the birds a better chance. These included setting up a "master plan" for the wild and captive birds, involving the Fish and Wildlife Service. The plan involves establishing at least five more populations in the wild and more groups in captivity, and forming at least one population on the mainland, probably at Houston Zoo in Texas. All these groups would be managed as a single population to ensure genetic variety.

Field biologists were advised by those at the workshop to use techniques such as genetic fingerprinting to identify the parentage of individual birds—a first step to setting up a studbook for the species. For this the workshop recommended the Arks database and the Sparks record-keeping program, both developed at Minnesota Zoo, and Medarks, a medical database. These would give field biologists access to some of the expertise on small populations built up in zoos. There was also a need for practical action, including provision of better food supplies, routine veterinary care and gathering more information on the parrot's behaviour.

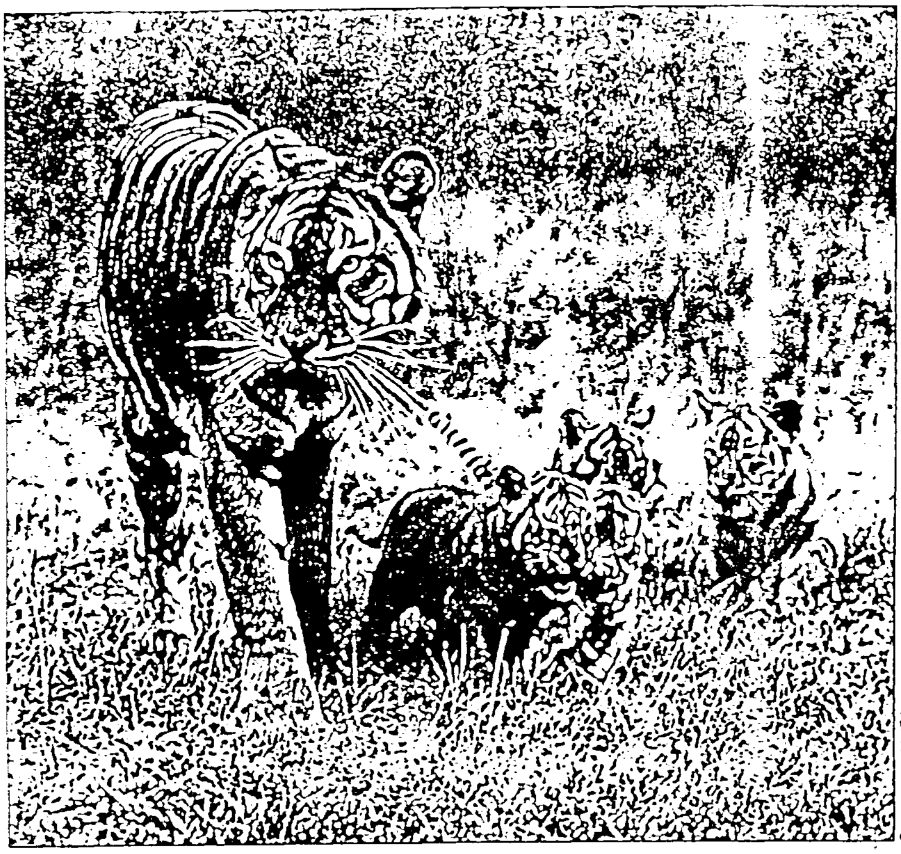
The computer analysis which formed the basis of these recommendations involved a simulation of the parrot population based on a computer model developed in 1980 by James Grier, of North Dakota State University. The model calculates the probability of extinction over a specified period, either starting from the actual number of birds and the ratio of males to females or from a hypothetical population.

In addition to this basic model, Bob Lacy, of the Brookfield Zoo, Chicago, and a member of the IUCN's captive breeding group, has added programs that simulate the mean population growth, carrying capacities, effects of various environmental conditions on reproduction, and the impact of catastrophes.

The basic information for the modelling came from field biologists who had studied the Puerto Rican parrot. Their data were run through the model thousands of times with different parameters, to calculate the probability of the population surviving over the next 100 years. It showed that neither the carrying capacity of the habitat nor environmental variation in the Luquillo forest have much impact on the wild birds' survival. The main factors controlling the rate of extinction were disease and natural catastrophes such as hurricanes. Lacy estimated that the wild population of parrots would be halved if a hurricane hit Puerto Rico.

In June 1989, the chance of a hurricane hitting the island in the next year was reckoned at one in 30. A month later, Hurricane Hugo blasted through Puerto Rico. Just as the model predicted, half the parrots were lost. Lacy believes that most of the birds died after their feathers were blown off or because they were blown out to sea. The hurricane also destroyed much of the forest, leaving the parrots vulnerable to hawks.

According to Lacy, there are around 30 wild birds left. He says things could have been much worse but for the fact that some of the workshop's recommendations had already been implemented. Captive birds already had good indoor cages, and a food store had been organised. "We now face a dilemma," says Lacy. "Do we take all the birds into captivity or do we carry on following the recommendations from the population viability analysis?" Discussions are continuing, but the least those who attended the workshop now have confidence in the accuracy of the computer's predictions. ☐



Gérard Lacz/NHPA

Candidates for the megazoo: despite this healthy litter of kittens the population of Sumatran tigers is shrinking rapidly. Plans to manage the species need to be made now. A "survival plan" for the Bali starling may be too late to save it from extinction

Hans Reinhard/Bruce Coleman

are especially difficult to observe in the wild. Information on the age and number of animals of each sex, for example, came from measurements of footprints. (Adults leave bigger prints, and if small prints accompanied the larger ones, then that adult was likely to be female.) After a workshop on the Javan rhino, attended by the captive breeding group, members of the Indonesian Conservation Department and field workers, the group made a series of recommendations based on the results of the population viability analysis. In particular, the group recommended that both wild and captive animals should be managed as a single population. It also emphasised the need to transfer techniques developed in captivity to animals in the wild. "While it is necessary, it is no longer sufficient merely to protect endangered species *in situ*. They must be managed," said Foose.

The workshop stressed the need to continue to protect the rhinos at Ujung Kulon and for a field programme to gather more information by tagging them with radio devices. There were also some more controversial suggestions. One was to set up at least two populations in captivity. A second was to move some of the animals from Ujung Kulon to other reserves in areas where the rhino used to live. When necessary, animals would be moved between the groups to ensure that genetic material mixed and that genetic diversity was preserved.

The idea is ambitious and will not be easy to follow through. In a zoo it is relatively simple to observe animals and even to take blood samples. For the programme to work, the same sort of information on the biology and pedigrees of the wild animals is needed. But these animals live in dense tropical forest and are difficult to find, let alone recognise as particular individuals.

Artificial insemination and embryo transfer are almost routine procedures in zoos today (see "Sperm you can count on", *New Scientist*, 10 June 1989). In the wild, these techniques could invigorate dwindling gene pools without the problems of moving animals. But they are practically impossible to carry out outside a zoo. As Bill Holt, of London Zoo, points out, the techniques rely on the female being in oestrus, and complicated hormone assays are needed to check that the animal is ready. These tests can be done only in a well-equipped laboratory—and once the results are known speed is of the essence. Simple logistics rule out any attempt at these procedures in the field.

Gilpin also points out that the techniques of zoo management are an expensive way to guarantee the survival of wild populations. But he admits that for very small populations it is not practical just to leave the wild animals to their own devices. Ideally, he would like to see some of the legwork—such as population viability analysis—done before a species becomes an emergency case. At that stage it should still be possible to protect the animals in other ways, by improving the habitat they live in and protecting them from disease.

Many animal rights groups and conservationists worry about the ethics of interfering with animals in the wild. The proposed management plan for the wild Javan rhinos has met opposition, both from conservationists involved in last year's workshop and others. The main concern was about the number of animals that could safely be taken from the wild.

In the US, the Fish and Wildlife Service has run into a similar problem in its efforts to manage the Florida panther. Plans for a captive breeding programme, devised at another IUCN workshop and based on population viability analysis, have been held up because of protests from pressure groups.

The workshop, held last November, included members of the captive breeding group, representatives from Florida zoos and other interested agencies under the umbrella of the Florida Panther Interagency Committee. They recommended an immediate programme of captive breeding and more management of the animals in the wild. They also suggested expanding the scheme to reintroduce the animal to the wild, while at the same time increasing efforts at conserving the panther's habitat. The captive breeding programme would involve the Department of Fish and Wildlife, a private captive breeding facility and zoos.

The plan was to take four wild adults and six kittens in 1990, and then one pair of adults and six kittens a year for the next two years—but not a single panther has been taken from the wild so far. Trapping should have begun last spring in the Everglades National Park, but there was an outcry from the public.

Jasper Carlton, coordinator of the pressure group Earth First!, is not convinced that the Fish and Wildlife Service can successfully breed and release Florida panthers into the wild. Carlton's movement and others urged the Fish and Wildlife Service to change its programme, taking only kittens, and only on an experimental basis. They reason that every adult taken from the wild population reduces the species' chance of survival in its natural habitat. Kittens have a low chance of survival in the wild and stand a better chance in captivity. Carlton calls for a greater commitment to restore and enhance the panthers' habitat. Captive breeding programmes have an unhappy history in the US: Carlton points to the demise of the Californian condor and black-footed ferret, both of which were taken into captivity in a last-ditch attempt to save the species. "We doubt whether these species will ever successfully recover in the wild," says Carlton.

"If they do the same with the Florida panther there will be a fight on a national scale," says Carlton. He does not object to the principle of captive breeding programmes, but he is worried about them taking place in commercial zoos, as will be the case with the Florida panther. "The Fish and Wildlife Service have decided to put genetics ahead of habitat protection," he says.

Foose says that the zoos selected for the panther project are all involved in conservation, and that a good deal of effort is going into protecting and improving habitats suitable for both the black-footed ferret and the Californian condor, so that captive-bred animals will have somewhere to live when they are released into the wild.

Ulysses Seal, chairman of the captive breeding group says: "When a species is endangered there are always a lot of conservation groups involved. There are also a lot of suggestions based on science, without any science being done."

He supports the survival programme for the Florida panther and believes that population viability analyses will help in getting things done quickly. "What we want to do is prevent the extinction of any species through neglect," says Seal.

Both Foose and Seal believe that in the next 50 years at least 1500 species will need a species survival plan involving captive and wild populations. These range from the Bali starling to Sumatran tigers, Asian lions and the African elephant. Their vision is of a world where zoo populations and wild populations complement each other; where humans carry out migrations when no natural corridors connect the animals—a world where good management exists for all animals. Yet Seal stresses that close management will be necessary only until wild populations are able to sustain themselves and are secure."

The first steps have already been taken. Computer databases, analysis programs and techniques in genetics and reproductive biology have helped zoos to breed and reintroduce endangered species such as the golden lion tamarin and the Arabian oryx. Some of the techniques that have helped these animals are now becoming available to field workers. But the success of species survival plans depends on acceptance by other conservationists, many of whom have different views on the best way to stop extinction. □

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