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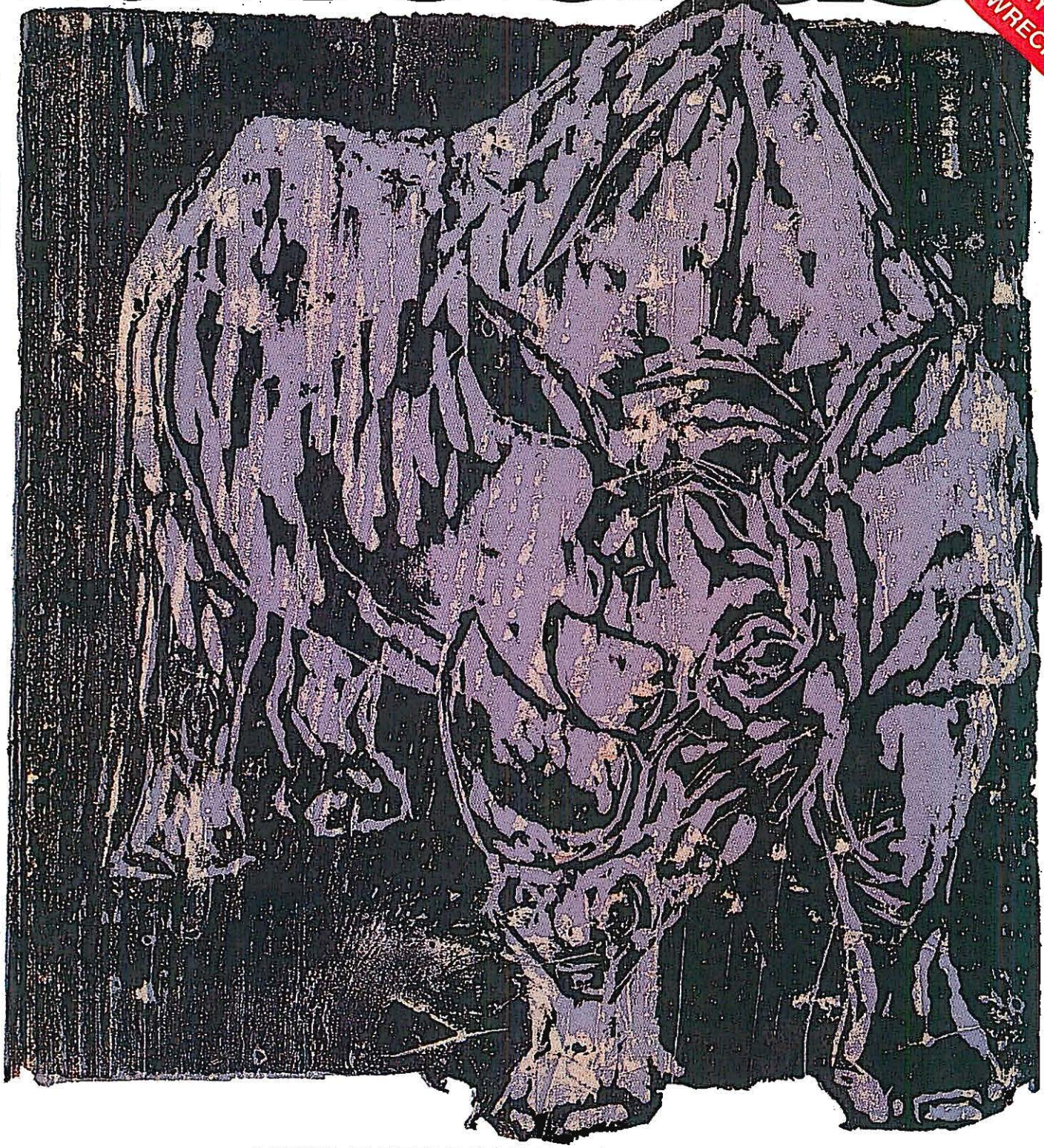

THE RHINO'S LAST STAND

A laser clock for rock
Letting the Loire run free
Titan: a moon like Earth

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Time to save rhinoceroses

Five species of rhino walk the Earth, but all of them face extinction. Conservation schemes could keep these creatures alive

Colin Tudge

PEOPLE—even biologists—have often suggested that the world's rhinoceroses are endangered because evolution has overtaken them; because they cannot compete with antelope and cattle, and other comparative newcomers. Not so. In their glorious past, which stretches back 50 million years, rhinoceroses have been the most varied and versatile of all large mammals, and have dominated a vast array of ecosystems (see Box). Until recent centuries, and in some cases until recent decades, each of the remaining five species has roamed over huge areas in their hundreds of thousands. They have become rare not because they are unable to compete, but because they have been shot.

Aviva Halter

But, as emerged encouragingly from the International Rhino Conference in San Diego*, when the shooting stops, rhinos can recover, even, sometimes, when extinction had seemed inevitable. Yet there is no room for complacency. Overall, the world's total rhino population—around 11 000—is about half the figure that is now, conservatively, considered "safe". The Javan rhino, reduced to around 60 individuals, has become the rarest large mammal on Earth; and the northern race of Africa's white rhino, now numbering around 40, is one of the rarest sub-species. Huge, coordinated efforts are needed—biological, diplomatic, judicial, financial and even military—if rhinos are to be saved. But they have shown themselves to be such resilient creatures that salvation must be considered possible.

Each of the five species has its own problems, which are worth discussing in turn; but each, too, illustrates broad principles of modern conservation that apply to all of them, and to all large vertebrates.

Both of the two African species, the black rhino and the white, are threatened in the medium term by Africa's rising human population; but neither has yet run out of habitat. As Tom Foose of IUCN (the World Conservation Union) observes: "Rhinos, like so many of the megavertebrates, are species that vanish well before their habitat disappears." It is poaching that endangers them, and—the San Diego conference, agreed—is the principal immediate threat for all rhinos, even the three in crowded Asia.

The conservation of both African species (and in principle also of the Sumatran and perhaps the Javan) is also complicated by their division into distinct races. A western, eastern and southern form are recognised among the black rhinos, though the genetic differences between the races are not great. The northern and the southern whites, however, have apparently been genetically separate for about 500 000 years, and are clear subspecies. Conservationists now seek courses of action that are least likely to cause regrets in the future: and the "policy of minimum regret" for African rhinos is to keep the different "races" of each species separate for as long as possible. This means, however, that large populations of each racial type must be maintained—which doubles or triples the conservation task.

Black rhinos once extended more or less continuously from Cameroon in the west to Somalia in the east, and down to the southernmost tip of Africa. Now only about 3500 are left in Africa, with another 170 or so in zoos. The decline has been prodigious: some at the San Diego conference put it at 95 per cent, and others at 98 per cent, with most of it occurring within the past 20 years. Four countries, however, now have stable populations: Kenya, Namibia, South Africa and Zimbabwe. But Kenya's approach to conservation differs sharply from that of the three southern African countries.

Kenya had 20 000 black rhinos in the 1960s, and fewer than 300 by the end of the 1970s. Extinction seemed inevitable. But in the 1980s the Kenya Wildlife Service (KWS) established 11 special reserves under the management of Rob Brett, who initially was seconded from the Zoological Society of London. Within these reserves, the remnant rhinos have flourished. One sanctuary population increased by 15 per cent between 1986 and 1989, with an increase in one year of 12 per cent. This is hardly repeatable (that particular reserve had an "unstable" population, heavily weighted towards young females); but the average rate of increase is 5 per cent per year, which is not bad for an animal that produces just one calf after a 15-month gestation.

The present Kenyan population stands at 400 animals. Brett estimates that the reserves could carry 680, a figure that could be achieved by the end of the century.

There are snags, however. To be gloomy, 680 is not really enough (as discussed later), and it is hard to see where else black rhinos can live in large numbers. Then again, no present sanctuary contains more than 60 animals, which may be too small to be viable in the long term. Of more immediate concern is the fact that at least 100 of Kenya's 400 black rhinos still live outside the sanctuaries, and bringing them inside is expensive and difficult. For one thing, black rhinos in residence do not always take kindly to newcomers.

KWS director Richard Leakey seeks to impose total protection. Trade in rhino horn—which is the chief immediate threat to rhino survival—must be stamped out entirely, he says, or the temptation to poach will continue. With much publicity and acclaim, Kenya has burnt consignments of ivory and horn in recent years. Leakey acknowledges the need for wildlife conservation to reward the local people, for they have rights too, and without their cooperation conservation is doomed. But

tourism already supplies one third of Kenya's income, and the animals are the chief attraction.

However, the greatest number of black rhinos live in southern Africa. Zimbabwe has about 2000, more than half the world total. The southern Africans do not believe that tourism alone can provide them with the income they need to sustain conservation as part of the local economy. In the words of Rowan Martin, of Zimbabwe's National Parks and Wildlife Management, "the black rhino is a species with no legal economic value which is nevertheless very expensive to protect"; however, "sustainable utilisation of rhino and rhino products offers a promising conservation alternative". So the Zimbabweans are pressing the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) to allow limited, strictly government-to-government trade in ivory and horn.

The Kenyans feel that the Zimbabwean initiative will scupper their own hands-off policy. The Zimbabweans reply that they now have a third of their country under wildlife management. So lucrative are the various trades in wildlife, which at present include sales to zoos and private owners, that this land is being taken out of cattle and goat farming to give back to wild animals. In short, their policy works.

The dilemma seems absolute. If Kenyan puritanism prevails, then the southern African economy will suffer and so, therefore, will the animals. If trade in horn is allowed, then the Kenyans will find it very hard indeed to keep their sanctuaries safe. The issue is not moral—when conservation works, surplus animals must be culled, or ecological disaster ensues; and besides, wild animals do die natural deaths and their horns can be harvested. The real problem is practical. How can customs authorities distinguish between horn or ivory from Kenya and horn or ivory from southern Africa? Many are pinning their hopes on a new analytical approach which uses the relative amounts of various isotopes in animal tissues to trace where the animal was raised (see the sequel to this article).

Another area of controversy is whether the world's niggardly investment in conservation should be spent in the wild, or at least in reserves within the animals' own countries, or on captive breeding, possibly in other countries, such as Europe or North America.

In reaching sensible decisions in conservation it is vital, wherever possible, to quantify. So Zimbabwean ecologists in 1988 created a mathematical model of conservation strategy, to see which of many possible approaches would be most cost-effective. The single most important requirement, their model showed, was to increase the speed with which gangs of poachers were detected. The model showed that one warden would be needed for every 20 square kilometres to raise population growth from zero, which it was in 1988, to 3 per

Rhinos: the power and the glory

RHINOCEROSES, along with horses and tapirs, are perissodactyls—odd-toed ungulates. The perissodactyls have been extremely successful and widespread, especially the rhinos, for more than 50 million years, and their fossil record is vast and complicated. Don Prothero, of the Occidental College, Los Angeles, and his colleagues, have for some years been reassessing the entire group.

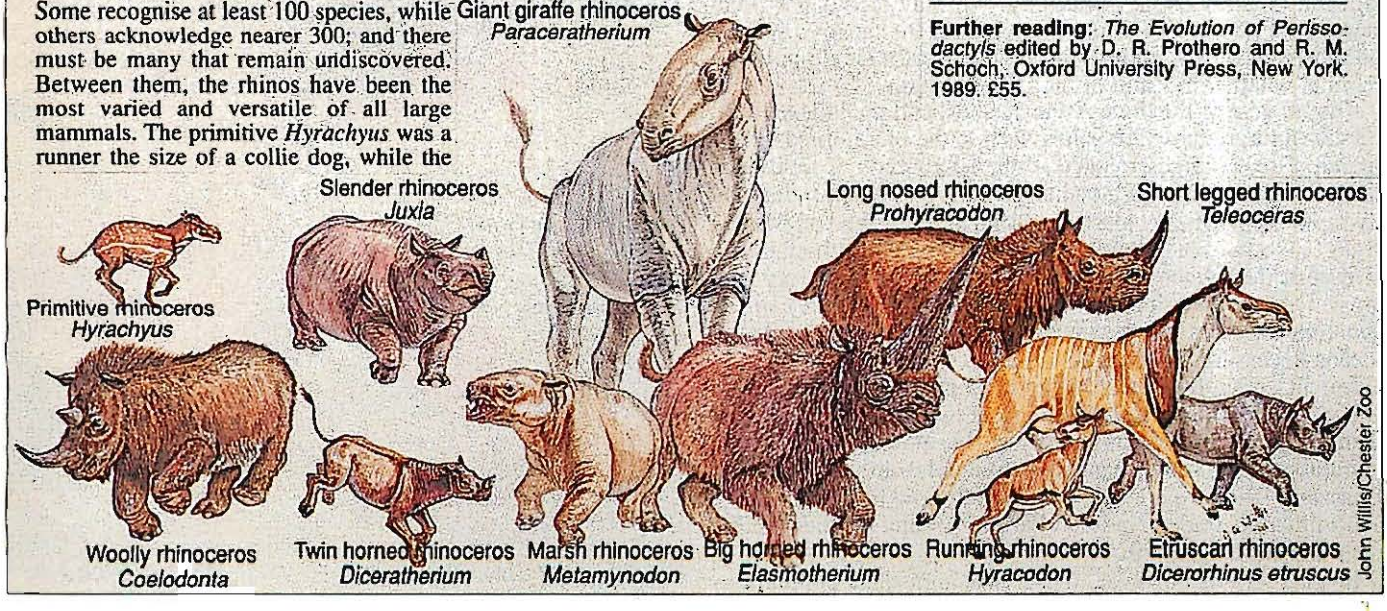
Forty million years ago, says Prothero, there were three families of rhinoceros; which he places in the superfamily, the Rhinoceratoidea. Two of the families—the Amynodontidae and the Hyracodontidae—are now extinct. All five living species belong to the third family, the Rhinocerotidae.

Taxonomists recognise more than 65 distinct genera among the Rhinoceratoidea. Some recognise at least 100 species, while others acknowledge nearer 300; and there must be many that remain undiscovered. Between them, the rhinos have been the most varied and versatile of all large mammals. The primitive *Hyrachyus* was a runner the size of a collie dog, while the later *Juxia* was a horse-sized runner. Many rhinos—especially the amynodontids, but also some rhinocerotids—were hippo-like, including *Teleoceras*. Some were more hippo-like than hippos. Only the rhinocerotids had horns, which were often bizarre. *Elasmotherium*'s single horn, based both on nose and forehead, was enormous. Several species, like *Diceratherium*, had nose-horns side by side. Many rhinos were hairy. Some were giraffe-like. One of these, *Paraceratherium* (otherwise known as *Indricotherium* or *Baluchitherium*) stood more than 5 metres at the shoulder and weighed about 20 tonnes; the biggest land mammal that ever lived, by far.

Between them, these early rhinoceroses dominated many an ecosystem in every continent except the Gondwanan land masses of Antarctica, South America and Australia. They reached Gondwanan Africa only 25 million years ago; comparatively late in their history. Not every lineage truly became extinct: some simply evolved into something else. Those that did die out—like most megavertebrates—were probably eliminated by changes of climate, and consequent changes in vegetation. The North American rhinos, for instance, once extremely important, became extinct at the end of the Miocene, 5 million years ago, which effectively was the beginning of the modern ice ages. Some very late forms, such as the woolly rhinos of Europe, may have been helped on their way by human hunters.

The five surviving rhinos, all tank-like in form, were also extremely successful, until people started shooting them. □

Further reading: *The Evolution of Perissodactyls* edited by D. R. Prothero and R. M. Schoch, Oxford University Press, New York. 1989. £55.



cent per year. Such protection would cost $400 per square kilometre (though management in the wild is more usually estimated at around $200 per square kilometre). Zimbabwe accordingly intends to focus its conservation efforts on "intensive protection zones", totalling 12 000 square kilometres. It also intends to breed rhinos in captivity in Zimbabwe, though, and is committed to the IUCN Captive Breeding Specialist Group (CBSG) to provide black rhinos for herds in other countries.

The black rhino shows how quickly the fortunes of rhinos can change: from good to disastrous in a few years; and then, with luck, to recovery. The white shows this even more dramatically. The southern whites were so rare at the end of the 19th century that they were considered extinct. Now, thanks to protection in South Africa, they are the world's most common rhinos, numbering around 4800. This is perhaps, as discussed later, only about as many as modern theory suggests is truly desirable. But these are as many as can be accommodated for now, and South Africa is already allowing trophy hunting, which yields enormous revenue. Ideally, the surplus animals would go elsewhere—for example to Western zoos or ranches. But for the time being, nobody has room.

The northern white's story is precisely the opposite. Once the northern whites were common in the Sudan, Uganda and Zaire. Now there are only 42 in the world: 28 in Zaire's Garamba reserve; 12 in Dvur Kralove Zoo in Czechoslovakia (now much beleaguered under the country's new regime); and two at the San Diego Wild Animal Park. San Diego has bred many southern white rhinos (one female has had 10 calves) but whites in general are difficult to breed in captivity. They live in herds of males and females, and the females seem to need the stimulus of some new male to make them receptive. Only zoos that can keep well-balanced social groups and can ring the changes in males succeed in breeding. The single pair now at San Diego is not the right grouping at all.

Drawing back from the edge

The northern whites in Zaire are doing well. According to Kes and Fraser Smith, working for the Garamba Project for IUCN, the present 28 has grown from a nadir of only 15, recorded in March 1984; an enormous mean rate of increase of 9·68 per cent per year. The first third-generation calf since the project began has just been born. This increase, say Smith and Smith, vindicates the initial decision to leave the rhinos where they are, instead of moving them to a sanctuary, or into zoos. Yet they emphasise the remaining dangers of fire and elephants changing the habitat, of potential inbreeding, and—still the greatest threat—poaching. We may also add a point raised by Foose, that it is not desirable for the fate of a species or subspecies to be entirely in the hands of a single political regime, whether in Zaire or the US or Britain.

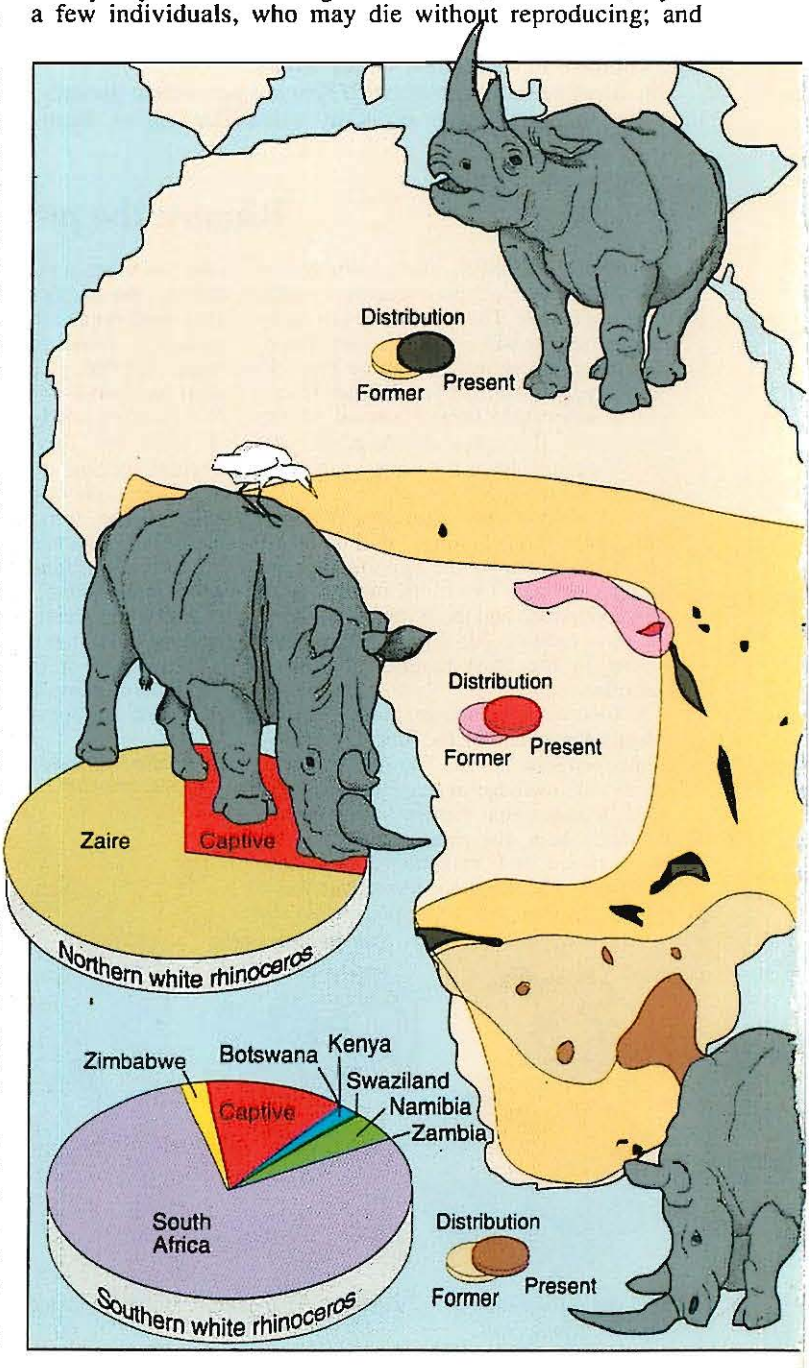
The biggest of the three Asian species, and the tallest of all rhinos (though the white is heavier), is the one-horned Great Indian. Great Indians roamed in their hundreds of thousands from Pakistan, through the Ganges valley of north India, and east into Nepal, Bangladesh and Bhutan, until the late Middle Ages. Like the black, but unlike the white, Great Indians are browsers, though they like especially to "browse" on very long grass. One square kilometre of the wild sugar cane *Saccharum spontaneum* can support as many as 13; big animals are by no means necessarily thin on the ground.

But in about 1400 people began to move into the Ganges valley in large numbers, and the rot set in. Now there are fewer than 2000 Great Indians in the world, and the only viable populations (of more than 50 individuals) are in the Royal Chitwan National Park in Nepal, which now has around 400, and in the Kaziranga National Park in Assam, northern India, with an estimated 1500.

In past years, however, these two important populations were far smaller. In the early 1960s, for instance, after a decade of heavy poaching, the number of Chitwan rhinos was reduced to between 60 and 80: the population seemed doomed. Then in 1962 the Nepalese government imposed rigorous protection, with the aid of the army. Since then the population has steadily recovered. Like the southern whites of Africa, they have proved that rhinos can be very resilient when given a chance.

The small figure of 60 to 80 reached in the 1960s was even worse than it may seem. What counts, for recovery, is not the total population but the "effective" population: those animals which are of the right age to breed and which are able to find mates (preferably ones to whom they are not closely related). Generally, only one in five individuals in a wild population is effective (though the proportion in managed captive herds should be much higher). The effective population in Chitwan was, at its lowest, an estimated 21 to 28.

When populations reach such low levels, they pass through a "bottleneck". Small populations rapidly lose genetic variation: partly because some genetic variants are carried only in a few individuals, who may die without reproducing; and



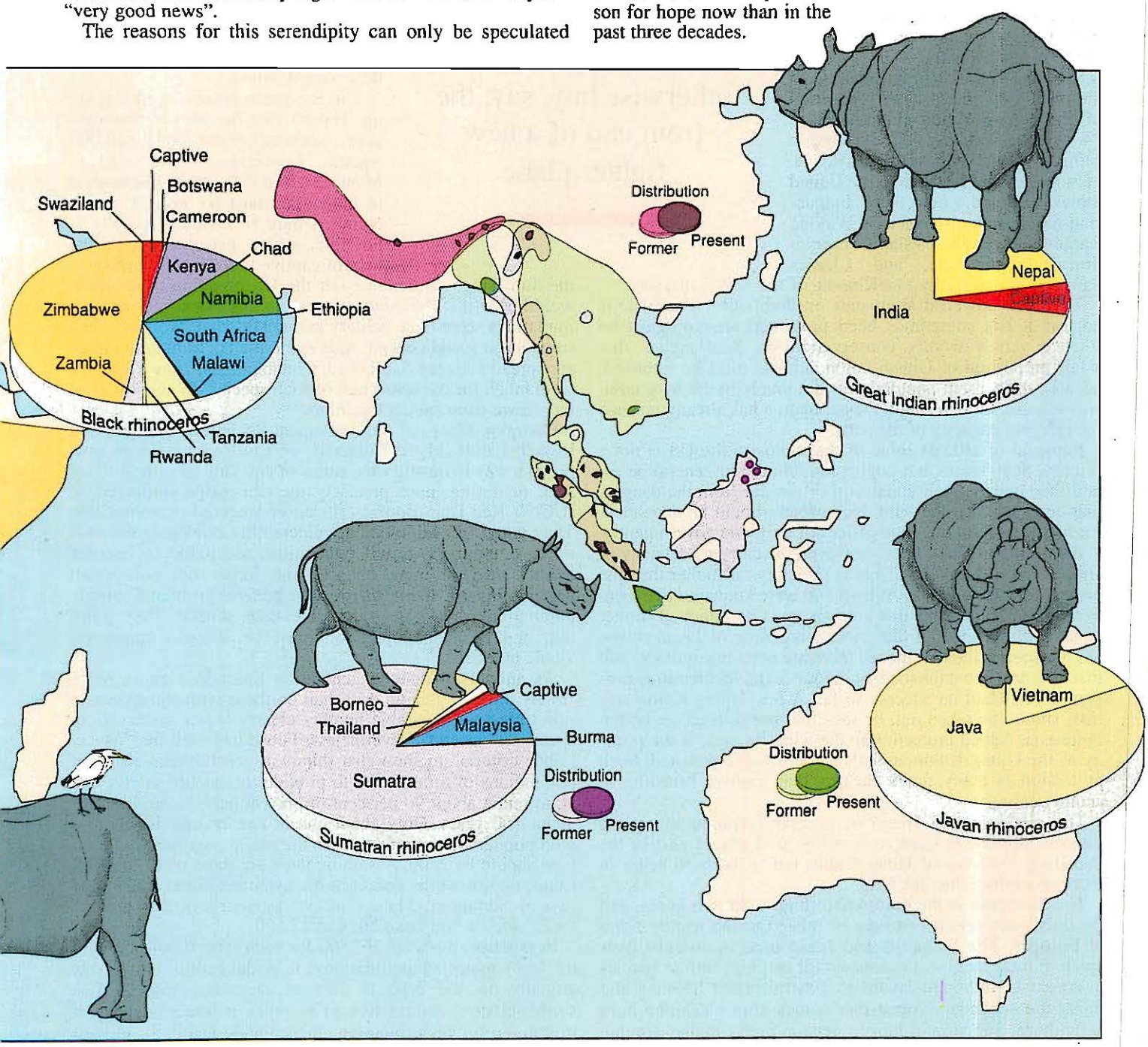
partly because each individual passes on only half of his or her genes to each offspring. In small populations in particular there is a fair chance that many genetic variants will not be passed on at all. Such loss of genetic variation—"genetic drift"—leads to inbreeding and reduces the evolutionary potential of the population as a whole.

So geneticists feared that the Chitwan population, because of the earlier bottleneck, would run into trouble even though its numbers were recovering. They suspected too that the genetic variation would have been fairly low even before the rapid decline of the 1950s. After all, big animals are supposed to be innately rare in any one place. Only big populations, thick on the ground, can sustain high genetic variation.

Yet here is another upbeat story. Eric Dinerstein, now of the World Wide Fund for Nature (WWF) in Washington, and Gary McCracken of the University of Tennessee, have analysed various representative proteins from the Chitwan rhinos—which directly reflect genetic variation—and found that the variation is still remarkably high. This, as McCracken says, is "very good news".

The reasons for this serendipity can only be speculated upon. One factor, says McCracken, is that the Great Indian species has been around for a very long time, probably hundreds of thousands and perhaps even millions of years—plenty of time to accumulate mutations. Another is that numbers were very high until recent centuries, so there were plenty of animals to contain all the genetic variants. Also, Indian rhinos are nomadic rather than territorial, so their gene pool has been enriched by genetic mixing between locations.

McCracken also stresses that the bottleneck occurred very recently, in the 1950s. Rhinos have a long generation time (around 12 years), so only two or three generations—and hence two or three opportunities to lose genes—have passed since then. Moreover, the bottleneck did not last long. Recovery began almost immediately. It is during prolonged bottlenecks, in populations that remain very small for many years, that loss of genetic variation is dramatic. Even so, the Great Indians are not yet out of the wood. Nepal is still a poor country. The biggest remaining population, in the Indian state of Assam, lost 58 to poachers in 1989. But there is more reason for hope now than in the past three decades.



The Javan rhino is a small, close relative of the Great Indian; indeed these two are the only remaining rhinos that share a genus (*Rhinoceros*). The Javans once ranged throughout the whole of Southeast Asia. Now, only 60 or so are left: 12 to 15 along the Dong Nai River in Vietnam; and 50 or so in the 300 square kilometres of the Ujung Kulon National Park in the western tip of Java.

What to do to save the remaining Javans has, of late, been highly controversial. In 1989 Ulie Seal and Foose from the CBSG carried out a "population viability analysis" of the Ujung Kulon population. They took into account all the factors that could conceivably affect survival—including likely breeding rate, calculated loss of genetic variation, poaching, and even total wipeout by an epidemic (a fate suffered by the Ujung Kulon rhinos in recent decades) or by nearby smouldering Krakatoa. Such an analysis is bound to include many estimates and probabilities but is a great improvement on hand waving.

Seal and Foose recommended, from their analysis, that a large proportion of the Ujung Kulon rhinos—18 to 24—should be taken out, and bred in captivity. Some of these chosen rhinos, they felt, should be taken to the United States, to found a herd there. Indonesian-based biologists such as Widodo Ramono, of the Indonesian Conservation Subdirectorate, and Charles Santiapillai and Kathy MacKinnon, of the WWF, disagree.

There are powerful arguments on both sides. The issue is not, as it has sometimes been presented, one of gung-ho science versus woolly conservationism. Seal argues that a fair proportion of Ujung Kulon animals must be removed, because the present population is not viable in the long term, and because, though small, the population has already reached the carrying capacity of the park.

Removal of at least some of the rhinos to the US is not a priority, Seal insists, but populations should in general be established outside their country of origin, far from the dangers that beset them in the wild. No species should be dependent for its survival on the good offices of only one government.

According to Santiapillai, however, the carrying capacity of Ujung Kulon is unknown, and is probably far higher than the present 60 or so animals. At least 100 were known to live there in the past. He accepts that animals must be removed sooner or later, but points out that captive breeding of Javan rhinos has not been achieved (indeed there are none in captivity) and that the newly-established Sumatran captive breeding programme has had no success so far. A few Ujung Kulon animals should be taken out, he says, but put in reserves within Indonesia. Added protection in the wild, he says, is the priority as the Ujung Kulon animals are still being poached. Such protection is many times cheaper than captive breeding in another country.

The mood at San Diego in general favoured this more cautious approach. Captive breeding will play a part in the hoped-for recovery of Javan rhinos, but is likely to begin in Indonesia rather than the US.

The Sumatran is the only Asian rhino with two horns, and the only hairy species (it may be related to the woolly rhino of Europe). The Sumatran and Javan used to co-exist over much of their range—it is unusual for two big, similar species to co-exist—although Javans in general prefer lowland and relish the secondary forest that comes after slash-and-burn agriculture. Sumatran rhinos in general prefer higher ground, and seem to live as solitary animals. Yet they are also highly vocal, so, as with orang-utans, their solitariness may be deceptive.

Besides the matter of numbers—an estimated world population of 700 is not enough for comfort—Sumatran rhinos have serious problems. They are widely scattered, mainly through the central highlands of Sumatra. The individual populations are too small to be viable, and some are even reduced to single animals. Many of these are outside the national parks, and are easily picked off by poachers. Many are in forests that are being felled around them.

> To create a really safe array of rhinos, the world would need to spend $44 million in total. For that we could otherwise buy, say, the front end of a new fighter plane

Western zoos have acquired a few Sumatrans, as part of a formal rescue project. There are five in the US, and two at John Aspinall's Port Lympne Zoo in Kent, plus a few in captivity in Indonesia. These captures have been criticised, but some of the captured animals already carried the scars of poachers' snares and some, including those at Port Lympne, were in forests already scheduled for felling. In short, they were doomed.

The Sumatran rhinos need tidying up. Those living outside the protected parks, such as Kerinci Sablat (10 000 square kilometres) and Kayan Mentarang (16 000 square kilometres) in Indonesia, must be brought inside. Numbers must be raised as quickly as possible, where necessary with the help of captive breeding. Biologists at the San Diego conference felt the US breeding programme would benefit if the rhinos were all in one place, for although Sumatrans seem to be solitary in the wild, they probably need some loose social contact. At present, the US Sumatran rhinos are spread between San Diego, Cincinnati and New York.

So much for the status quo of each species. In general, how far are we from saving the rhinos?

Georgina Mace, of the Zoological Society of London, and Russell Lande, of the University of Chicago, have now proposed a way to quantify the status of any kind of animal. They seek to define more precisely the categories employed in IUCN's Red Data Books: critical, endangered or vulnerable. They note, for example, that vulnerability obviously depends on total numbers. Small populations are liable to become extinct through mere chance, and larger but still small populations are liable to run into genetic problems. Single populations are more vulnerable than several, they point out, and each subpopulation must be above a minimum viable number.

As animals with long generation times lose genes more slowly through genetic drift than do those with short generation times, the desirable number clearly varies greatly from species to species. Nevertheless, Foose has used the "Mace-Lande criteria" to show that rhinos in general need effective populations of around 500 to provide reasonable safety; that is, to retain about 90 per cent of present genetic variation for about 100 years. Only about one in five of individuals in a wild population are effective, so the actual population of each type should be 2500. Assuming there are three types of black rhino, two of white, one each of Javan and Great Indian and two of Sumatran (Malaysian and Indonesian), this gives a total "safe" world population of 22 500.

In practice, the total of 2500 for each type should be built up from many subpopulations; it is dangerous for all the animals of one type to live in the same place. Most subpopulations would live in reserves in their country of origin, but for each rhino type there should ideally be at least

one captive population in a different country, says Foose. The latter should be in zoos, with all the zoos of a region cooperating to manage and breed their rhinos jointly. Such joint breeding schemes already exist: called SSPs (species survival plans) in North America, and EEPs (European endangered species programmes) in Europe. Britain and Ireland hitherto have formed their own region but seem bound to join in with Europe. In general, no subpopulation, captive or otherwise, should number fewer than 120.

At present the subpopulations that exceed this number can be counted on the fingers of one hand. So, despite the recent successes, we are still a long way from saving the world's rhinos. And Foose stresses that the figure of 2500 for each type is really a minimum: twice that figure would be preferable. Only one individual subspecies, the southern white, is above the 2500 minimum, and even the southern whites fall short of the more desirable figure of 5000. Some types, notably the Javan and northern white, are appallingly low.

Foose has calculated the cost of sustaining desirable populations of rhinos, taking into account the fact that different species need different amounts of room. Whites are grazers, and very big: only 1·5 can fit in per square kilometre. The others are browsers of various sizes, in varying habitats: Great Indians in Chitwan need 2 square kilometres each, Foose suggests, while as many as 10 Sumatrans can squeeze into 1 kilometre of Indonesian rainforest. The cost of protection and management in the wild varies between $100 and $400 per square kilometre. Such considerations give a total cost for managing all kinds of rhinos in the wild, each with minimum total populations of 2500, of $17 million.

Captive breeding, in other countries, is far more expensive. Virtually no one would suggest it should be the first conservation priority, yet very few would suggest that it has no part to play. Zoos can and do sustain reserve subpopulations that can be far safer than any one population in the wild. Zoo subpopulations can be very well managed, with breeding arranged to reduce genetic loss (by drift) to a minimum, so that the proportion of "effective" animals is very high.

The costs of zoo animals, though high, are paid for mainly by visitors and thus are met by budgets that are separate from the funds that should flow to the wild. Besides, the total amounts spent on conservation by rich countries are so small that captive and wild conservation should not be at war with each other. They should cooperate for a greater share of the funds that all rich nations currently squander on useless things.

Foose envisages an ideal future in which captive subpopulations, rich in genetic variation, exchange genes with wild subpopulations. He envisages captive subpopulations of between 150 to 200 for each rhino type—a total of 1200 animals—the cost of which, he estimates, would be around $14 million per year. At present, the captive world population of all rhino types is around 650, which is half the minimum desirable number, and contains hardly any of the two Southeast Asian species.

For a really safe array of rhinos, then, with 5000 of each present type in the wild, and 150 to 200 of each type in captivity, the world would need to spend $34 million in the wild, and another $10 million in zoos: $44 million in total. For that we could otherwise buy, say, the front end of a fighter 'plane.

But first we must attend to basics; the most crucial of which is to curb poaching. This will be discussed next week. □

Colin Tudge is a zoologist and freelance writer. His latest book, *Last Animals at the Zoo*, is published by Hutchinson-Radius this month.

*International Rhino Conference, San Diego, 9-11 May 1991. Organised by Oliver Ryder, Center for Reproduction of Endangered Species, PO Box 551, San Diego, California 92112.