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Allocation of resources for conservation

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Theory dictates that conservation areas should be as large as possible. When money for their protection is inadequate, different considerations come into play.

IN THEORY, large nature reserves or parks reduce the risk of extinctions because they contain sizeable populations of endangered species of plants and animals. In practice, however, most developing countries do not have the resources to protect large areas and economically valuable species from illegal exploitation. Here we show that the rates of decline of rhinos and elephants are related directly to conservation effort and spending. The conclusion to be drawn from these results is either that conservation schemes must be adequately funded, or resources must be concentrated in small parts of large reserves, if local extinctions are to be avoided.

Since the 1930s, many developed and developing countries have established national parks and nature reserves. The aim is usually to protect ecosystems or large parts of them, together with their indigenous floras and faunas, in a state relatively untouched by human exploitation or occupation. According to conservation biology theory, large protected areas minimize the risk of extinctions arising from genetic isolation because they contain sizeable populations, corridors between parks further reducing isolation[1,2]. Several large conservation areas in Africa, such as Serengeti, Tsavo, Selous and Luangwa, come close to fulfilling these theoretical ideals, yet the recent declines of large populations of both black rhino (*Diceros bicornis*) and elephant (*Loxodonta africana*) within these areas[3,4] shows that there is a wide gap between theory and reality. In this article we examine the reason why this should be so — first, by evaluating a management strategy that failed to protect black rhinos and elephants from illegal exploitation in Luangwa Valley in north-east Zambia (Fig. 1); and, secondly, by considering the wider implications for the funding of conservation where resources are limited.

The socio-economic background of protected areas is relevant when looking at conservation schemes; although there are local variations, the example of Luangwa Valley[5,6] is fairly typical of many protected areas in Africa. The four national parks, totalling 16,660 km^2 in area, were orginally established as game reserves in the colonial era. The human inhabitants, who had previously used the areas' products both for subsistence (meat, firewood, honey) and trade (ivory, rhino horn), were evicted. People were allowed to remain in seven sparsely inhabited hunting areas, totalling 46,342 km^2 that border on the reserves, but were subjected to game and gun laws and to licence quotas set to protect wildlife. Hence, both reserves and hunting areas were managed increasingly for the benefit of outsiders, chiefly tourists and safari hunters, and earnings from wildlife went largely to central government and the private sector. Local residents, denied access to resources that were previously under their control, became increasingly impoverished and resentful.

In 1972 Zambia affirmed its commitment to conservation by gazetting 9% of its surface area as national parks and 22% as game management areas. At that time, Luangwa Valley held large populations of elephant (100,000) and black rhino (between 4,000 and 12,000). However, Zambia's economy then began to decline because of falling copper prices, and although central government spent quite heavily on conservation, the amount was low in relation to the vast areas under protection. Consequently, park infrastructure and law-enforcement efforts began to collapse. By the late 1970s, Zambia's internal socio-economic problems, coupled with dramatic price increases of ivory and rhino horn on the world market[3,4], had resulted in a serious outbreak of poaching in Luangwa Valley. By the mid-1980s elephants were reduced in numbers by 75% to around 25,000 and rhinos to probably a few hundred[3,4]. Profits from this slaughter went not to the Zambian mainstream economy, but elsewhere — the smaller share to organized gangs who killed and extracted ivory and horn from animals within the parks, and the larger share, including foreign exchange, to middlemen who smuggled the trophies out of Zambia. The slaughter provided little benefit to Luangwa residents, because most of the poachers came from areas bordering onto, but outside, Luangwa Valley.

In late 1979 an anti-poaching operation, funded in part by the Zambian government, was set up. The following year an external agency donated a relatively large sum in conservation terms (half a million US dollars over three years) to the operation. The government bought vehicles and mobilized staff into units that undertook regular foot patrols in important areas with the aims of arresting poachers and protecting rhinos and elephants[7].

In any such project, it is essential to monitor the numbers of animals under protection. We used an index of rhino abundance based on sightings made by patrols between 1979 and 1985 (Fig. 2). The reliability of the index was confirmed by comparing the results with a very accurate method of counting rhinos in one area[8] (instantaneous rates of decrease of

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A victim of poachers, its horn hacked off, is left to rot.

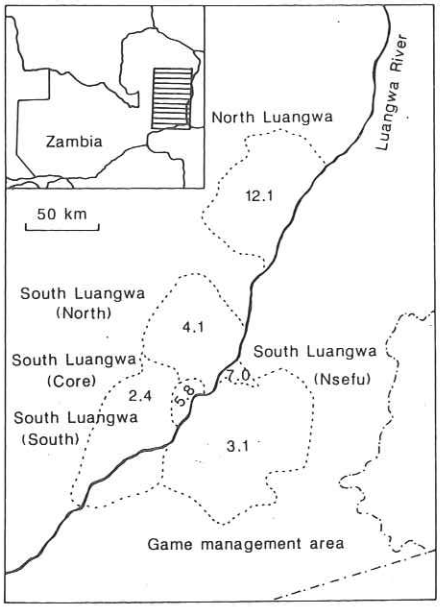

Fig. 1 Map of Luangwa Valley showing North and South Luangwa National Parks, the different sizes of six areas patrolled regularly and the frequency of rhino sightings per patrol in 1980 (see Fig. 2 for methods of assessment).

24% yr^{-1} against 29% yr^{-1}). Sightings of elephants (which are not depicted in this article) were monitored by patrols in the same way and produced similar rates of change to those obtained by aerial counts. Each area patrolled was of a different size, and patrol intensity varied between areas. At one extreme, the remote 4,636 km^2 North Luangwa National Park was visited by only 30 patrols totalling 322 patrol days. In contrast, a small area of 400 km^2 was designated as the core of South Luangwa National Park[7], and one or two patrols were permanently policing it from 1982, resulting in a total of 337 patrols (2,260 patrol days).

In spite of this protection, rhinos declined at an overall rate of 63% yr^{-1} throughout Luangwa Valley. However, their rates of decrease differed between areas, and varied between 24% yr^{-1} and 99% yr^{-1} (Fig. 2). Such high rates of decrease in a species with a maximum recruitment rate of 7–11% yr^{-1} resulted in the virtual disappearance of rhinos from most areas of Luangwa Valley between 1979 and 1985. By 1985 rhinos were seen regularly only in the two smallest areas, at frequencies of 1.78 and 1.04 rhinos per seven-day patrol (Fig. 2). Elephant numbers also declined at an overall rate of 12% yr^{-1} throughout Luangwa Valley. In one area they decreased at a rate of 42% yr^{-1} but in others, where there were fewer elephants to start with, their numbers actually increased at rates of up to 18% yr^{-1}. Elephants, however, are known to recognize areas of relative safety, and the increases probably reflect immigration rather than increased recruitment.

It is intuitively obvious — but infrequently demonstrated[9] — that the resources put into a conservation scheme will relate directly to its ultimate success. In Luangwa Valley there was a direct relationship between the rate of decrease of rhino and elephant numbers in each area and the patrol effort, corrected for both size of area and frequency of rhino and elephant sightings in 1980 (Fig. 3). Hence within Luangwa Valley the patrols did deter poaching, but the effort was too thinly spread, even in the core area, to prevent the decline of rhinos. Extrapolation of the linear regression for rhinos predicts that a decline in numbers could have been prevented if five separate patrols had permanently covered the core area. But, given the available manpower, to have achieved this would have meant the concentration of all patrols in the core area, leaving 98% of the total area unprotected[7].

A number of factors, such as external demand for trophies, poverty and corruption, result in poaching of rhinos and elephants. Given this, the detailed results from Luangwa Valley support the view that an important factor in the overall decline in rhino and elephant numbers across the rest of Africa is a shortage of manpower, and ultimately of resources, within national conservation departments[10,11]. Both black rhinos and elephants are widely distributed across Africa, often sympatrically but with rhinos always at lower densities than the more adaptable and wide-ranging elephant. Surveys during the 1980s provide information on gross population trends of both species in different countries[3,4]. As in Zambia, most large populations of rhinos and several large populations of elephants suffered serious declines. Rhino numbers remained the same or increased in only three countries, whereas elephant numbers increased in perhaps four. In 1980 a survey of manpower and spending by central government within conservation areas showed wide national differences[10,11], and there is a direct relationship between spending (corrected for total area) and the estimated changes in rhino (Fig. 4) and elephant numbers in each country. To achieve a zero decline of rhinos the regression predicts that spending should have been US$230 km^{-2} yr^{-1} (Fig. 4), and that $215 was necessary for elephants. Rhinos normally occur at densities of 0.4 km^{-2} — if all protection costs are attributed to them as the most sensitive indicator species, this was equivalent to $575 per rhino per year. In Luangwa Valley, with government spending of $11 km^{-2} yr^{-1}, the external donation given to Zambia should have been spent entirely within 725 km^2 over three years, confirming that all patrol effort should have been devoted to a relatively small area that would have held

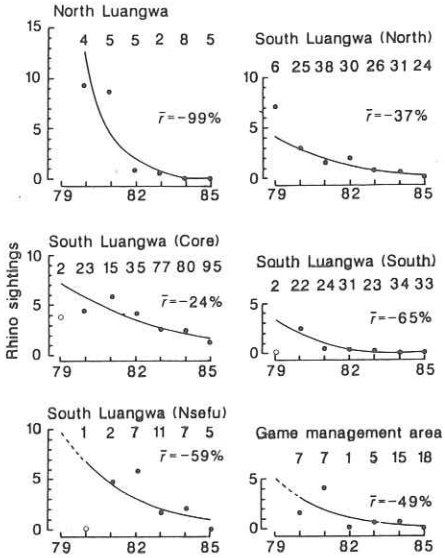

Fig. 2 Rates of decline of black rhinos in six different areas of Luangwa Valley, quantified from an index of abundance based on sightings made by anti-poaching patrols[11]. A total of 768 patrols of different duration were undertaken in all months of the year between 1979 and 1985. These data were heavily skewed due to the absence of rhino sightings on many patrols, and therefore were analysed using log-linear models with a Poisson error distribution. Patrol length, number of scouts, month, area, year and an area–year interaction all had a significant effect on the basic model and considerably reduced its deviance. To take account of different patrol size and duration, and of season, all sightings of rhino were adjusted in the model as if all patrols had been made by four scouts over a seven-day period in January. For reasons of clarity, values are depicted as adjusted means for each year in each area (sample sizes shown above year values), but curves were fitted through all data points. Instantaneous rates of decline, assessed by including year as a linear variable, showed a highly significant difference between the six areas. Some areas were not patrolled, or patrolled only lightly in 1979 or 1980, so rates of decline were calculated from the first year with >2 patrols, thus omitting open symbols. Dashed lines show extrapolations based on rates of decline from 1980 or 1981, as appropriate.

almost 300 rhinos. But because the external donation was spread over approximately 16,000 km^2, it added only a further $10 km^{-2} yr^{-1}, totalling less than 10% of the spending necessary to prevent a decline of rhinos.

This study is of wide relevance to conservation practice. Conservation biologists have concentrated upon theoretical implications of the size of protected areas and of reduced population size and inbreeding depression[2,12], but there are few empirical studies that evaluate the efficiency of resource use in achieving conservation objectives. Because of limited funding[10,11], theoretical aspects of conservation biology may sometimes obscure realistic goals for developing countries. Our results show that the rates of a species' decline are related directly to protection

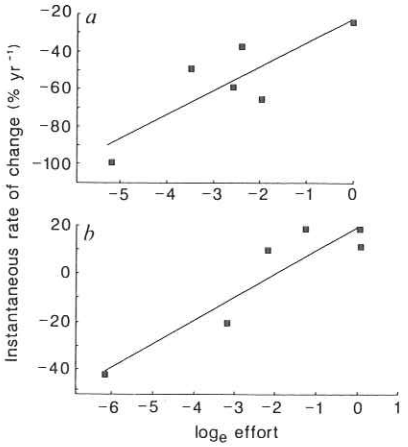

Fig. 3 *a*, Relationship between the instantaneous rate of decline of black rhinos (from Fig. 2) and patrol effort in different areas of Luangwa Valley. Because each area was of a different size and initially held different numbers of rhinos (see Figs 1 and 2), the effort for each area was calculated as $\log_e$ (total patrol days/size of area/frequency of rhino sightings in 1980). The regression equation was of the form $y = 0.13x - 0.16$ ($r^2 = 0.73$, $P < 0.05$). *b*, A similar relationship held for rates of change in elephant numbers and patrol effort, and the regression equation was of the form $y = 0.10x + 0.20$ ($r^2 = 0.83$, $P < 0.01$).

effort. If funding for conservation cannot be increased, then concentrating resources upon selected areas provides a pragmatic option for black rhinos and elephants, as well as for other endangered species, such as lowland gorillas or pygmy chimpanzees[13,14]. Indeed, the success of sanctuaries in stabilizing numbers of the few remaining black rhinos in Kenya in the past year or so, and the recovery from near extinction of the southern white rhino and the vicūna, has resulted from pursuit of such policies[15].

The relatively small sums that international conservation agencies have available to spend on valuable species in developing countries are most likely to achieve results in one of two contrasting situations — first, in low-spending countries only if they are concentrated at appropriate levels over small areas, such as the Kenyan rhino sanctuaries or the Virunga mountain gorilla population; secondly, over large areas only if the money is allocated to a relatively high-spending country like Zimbabwe, which is now in need of extra resources to prevent Zambians killing rhinos in the Zambezi Valley.

In poor countries, large conservation areas and sizeable populations of valuable species can probably only be maintained by a radical change in approach, combining the rectification of socio-economic problems[6,15] with more investment in park infrastructure and policing. The most realistic option lies with appropriately directed conservation and rural development projects funded by international aid agencies, either directly or through debt-swap schemes. In particular, residents of the areas concerned must be allowed to participate in plans for their local conservation areas[16]. If wildlife populations then recover, development can aim to become self-sustaining. For this to happen, earnings from sources such as tourism, licence fees and trophy sales must in part be recirculated, rather than going only to central government and business, both to pay for continued policing and to benefit local residents.

Such a project is now underway in Luangwa Valley[17], with the elephant as its linchpin. It is worth bearing in mind that at least 75,000 elephants have been lost from Luangwa since the 1970s. A ban on the licensed hunting of elephants was imposed in 1980 in response to the escalating poaching, yet the sale of between 100 and 200 licences to foreign hunters between 1980 and 1985 would have raised a sum equivalent to the external donation given to Zambia in 1980, without even considering the value of the ivory or of the meat for local people. The aim, therefore, must be to achieve more balanced accounting, to develop the area and its wildlife for the benefit of the human inhabitants and to replace the current conflict between them and protected areas with a custodial and participatory relationship that benefits both parties[5,6,17]. After the failure of underfunded protectionist policies in preventing serious declines in rhino and elephant numbers across Africa, schemes such as that now operating in Luangwa provide the best hope for the recovery of depleted populations and maintaining sizeable populations of valuable species in large conservation areas[1,2,12].

Our results demonstrate the principle that adequate resources need to be invested to achieve given objectives in conservation, whether for protection or development. Individual nations, funding agencies and conservation biologists together will have to determine policies which define how much conservation is enough and affordable, and make selective decisions instead of bowing to particular interest groups that believe all conservation is necessary. In determining how much conservation is affordable, the economic value of each species must be taken into consideration. Although

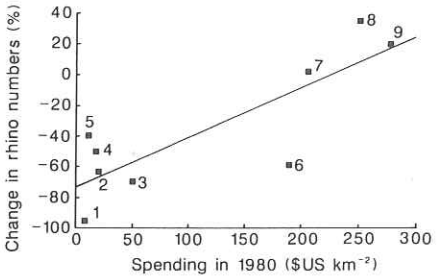

Fig. 4 Relationship between change in black rhino numbers between 1980 and 1984, and conservation spending in various African countries. Surveys of rhino numbers[4] were conducted in 1980 and 1984 and the percentage change was calculated for countries with > 250 rhinos in 1980 from these estimates as $(1980 - 1984/1980) \times 100$. Because the change in Zambia's rhinos was calculated with these independent data rather than from Fig. 2, Zambia is included in this figure. Details of spending per square kilometre by central governments on their conservation areas was available for nine of these countries[9,10]. 1 = Central African Republic, 2 = Tanzania, 3 = Somalia, 4 = Mozambique, 5 = Zambia, 6 = Kenya, 7 = South Africa, 8 = Namibia, 9 = Zimbabwe. The regression equation is of the form $y = 0.32x - 72.82$ ($r^2 = 0.68$, $P < 0.01$) and at 0% change had an intercept of \$230 km^{-2}. The census data for large populations (> 1,000) of elephants between 1981 and 1987 are of variable quality[3] but a similar relationship between changes in elephant numbers and spending appeared to hold for 14 countries. The relationship, which is not shown, is of the form $y = 0.24x - 51.97$ ($r^2 = 0.32$, $P < 0.05$) and at 0% change had an intercept of \$215 km^{-2}.

less valuable species or ecosystems may cost less to conserve, the required sum for rhinos and elephants will no doubt be higher today because of inflation and raised stakes. Both species are now more scarce, and ivory and rhino horn prices are still rising. An economic arms race is on and Africa — its people and its wildlife — will suffer yet further if it is not defused.

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