fallow will clarify the dynamics of shifting cultivation. This is a more useful approach than narrower emphasis on the field or swidden community itself and on its analogous status with the climax forest[12]. **The successional character of agriculture has long been** recognized[29], **and such an approach is particularly suitable for shifting cultivation, initiated as it is by artificial gap formation and substantiated by plant re-establishment and** seral **development through the field and fallow continuum.**

Traditional shifting cultivation is sometimes seen as an instructive model for small farmers in the tropics, with mixed cropping as an associated, adaptive cultivation strategy[9,10]. **While this approach is to be encouraged, it is evident that present understanding of the traditional cultivation system is imperfect and** needs refinement. **This is particularly so in respect of the compositional status and adaptation of the crop community, and of the functional relationships within the broader field and fallow' system. Additional investigation of these topics can yield information that is relevant to the development of productive, yet sustainable, small-scale cultivation systems for the tropics.**

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Africa's Elephants and Rhinos: Flagships in Crisis

David Western

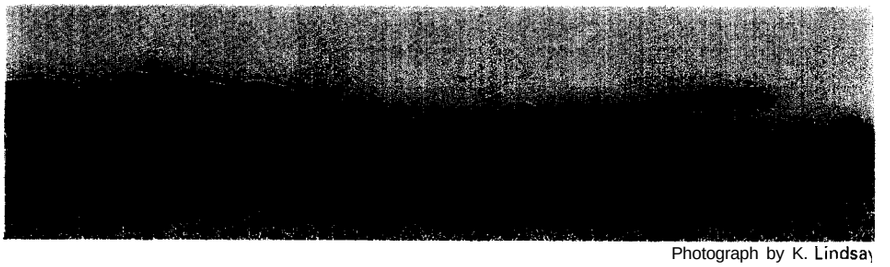
Despite extensive conservation measures over the last two decades, populations of elephants and rhinos in Africa continue to decline. The plight of the black rhino is especially acute. Poaching for rhino horn and ivory, rather than habitat loss, remains the principal threat to these species. The only long-term hope may lie in the effective protection of small, isolated populations.

All species of rhinos and elephants are either acutely endangered or threatened in the wild. As the largest terrestrial animals, they take on a special significance as conservation flagships. These charismatic mega-vertebrates, as they have been aptly named, are widely held to be threatened by loss of range and habitat' and to presage the fate of other large mammals.

Neither contention is true for Africa: habitat is still extensive and most large mammals are still relatively safe, with the exception of spotted cats and crocodiles which, in common with elephants and rhinos, are valuable trade species. Hunting, the more immediate threat, is likely to eradicate such commercial species long before habitat loss becomes critical[2]. Concerns over habitat loss in the tropics, though justified, should not blind us to a more urgent crisis. What is happening to pachyderms today is a repeat of what happened to the North American bison in the 1800s[3].

What is different about the modern slaughter is that the African governments, hoping to save species by protecting their habitat, have set aside vast national parks. Nearly 400 protected areas covering 1.2 million km^2 are spread throughout sub-Saharan Africa. Individually, many countries have made enormous sacrifices. Botswana, Malawi, Zimbabwe, Tanzania and Kenya, for example, have all set aside 8% or more of their land for wildlife.

However, elephants and rhinos belie the philosophy that saving the estate saves its tenants. As many as 500 000 elephants and 50 000 rhinos could survive in Africa's existing



Photograph by K. Lindsay

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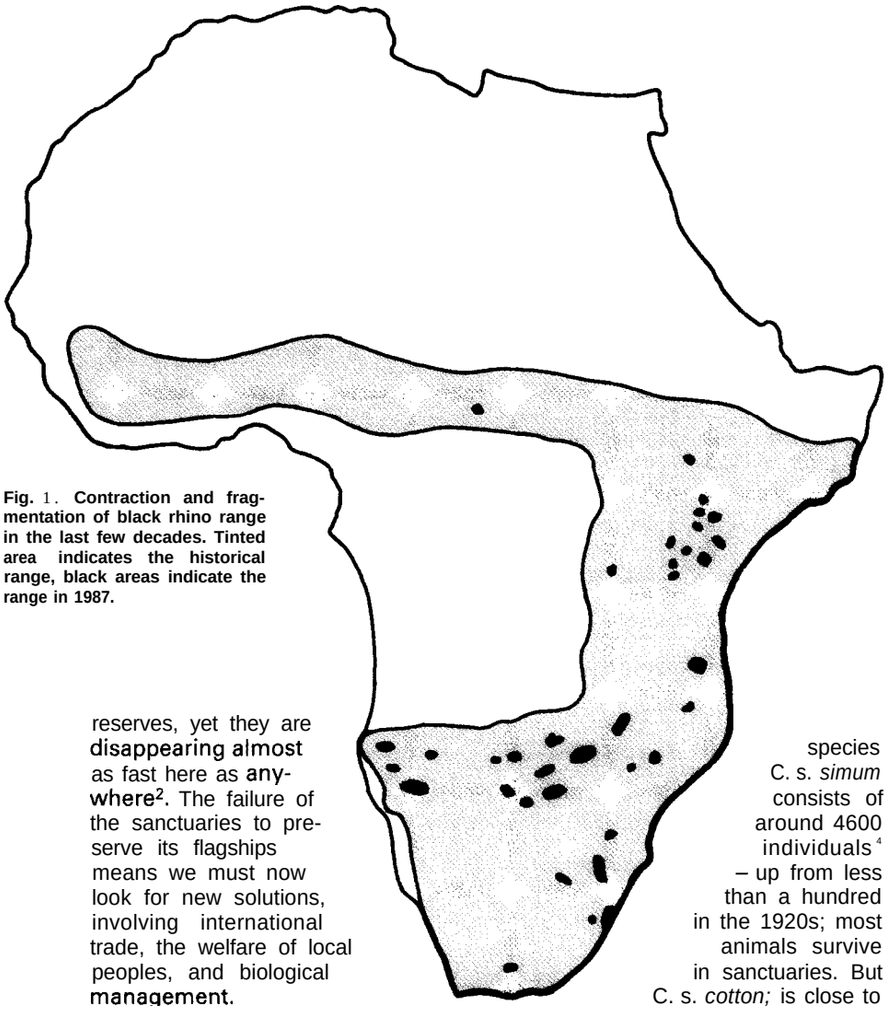


Fig. 1. Contraction and fragmentation of black rhino range in the last few decades. Tinted area indicates the historical range, black areas indicate the range in 1987.

reserves, yet they are disappearing almost as fast here as anywhere[2]. The failure of the sanctuaries to preserve its flagships means we must now look for new solutions, involving international trade, the welfare of local peoples, and biological management.

I briefly review the status of Africa's elephants and rhinos before looking at the conservation problems they pose and some of the remedies being tried.

Rhinos

Two rhino species, the black *(Diceros bicornis)* and white *(Ceratotherium simum),* were formerly spread over most of central and southern Africa.

The white rhino has a disjunct distribution. In southern Africa, the subspecies C. s. *simum* consists of around 4600 individuals[4] – up from less than a hundred in the 1920s; most animals survive in sanctuaries. But C. s. *cotton;* is close to extinction in the northern range where 18 animals survives, down from several thousands in the 1960s.

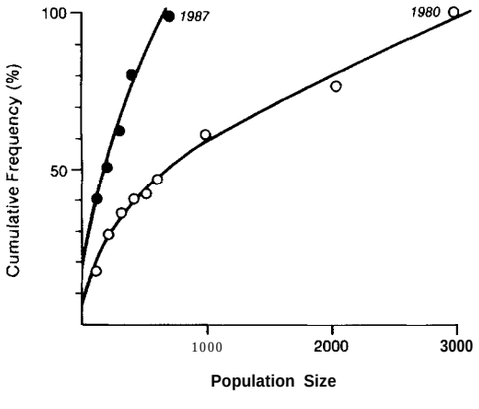


Fig. 2. Cumulative frequency of black rhino population sizes, showing heavy poaching on large herds in recent years.

The black rhino is faring worse. Last century its range covered most of Africa south of the Sahara, with the exception of the equatorial forests. Today between 70 and 100 isolated populations cover 3% of that range[4,6] (Figs 1 and 2). Few other species can have declined as precipitously as the black rhino. In the 1800s there were hundreds of thousands of individuals; in 1970 the total population stood at around 60 000, then dropped steeply to 15 000 in 1980, 8800 in 1984 and 3800 in 1987 (Fiefs 4 and 6). Repeat aerial counts of the three largest national park populations – Tsavo in Kenya, Selous in Tanzania and Luangwa Valley in Zambia – show the combined total down to some 250 in 1987 from 17 000 in the early 1970s, making the point that habitat loss is not a factor.

There is no doubt about what killed off the rhinos. Between the late 1960s and early 1970s rhino horn prices rose ten-fold on the international market, to around $8000 a kilo. Half of all horns are sold over the counter of traditional Chinese pharmacists in the Far East as an analgesic, the other half as ceremonial dagger handles in the Middle East, particularly North Yemen'.

Elephants

The status of the African elephant *(Loxodonta africana)* is less critical and more controversial. The species was more or less continuously distributed over Africa south of the Sahara until the 16th century. Today, despite rapid loss of range and increasing population fragmentation, the elephant still occupies 7.5 million km² (Ref. 2).

In 1979, when elephant numbers were estimated at 1.35 million, it was debatable whether the population was in decline'. One view held that losses were insignificant, and that natural mortality alone could sustain the international ivory trade[8].

Recent events attest to the other view, that elephants are in sharp decline due to ivory poaching[2,9,10]. Like rhino horn, ivory rose sharply in value, from $5.5 per kilo in the late 1960s to a present value of $100 per kilo[2]. The population dropped steeply to around 700 000[4]; computer models of the impact of the trade[9] and field data based on repeat counts of many locations[2,4] show the continental population halving every eight to ten years-three times faster than human growth and ten times faster than agricultural expansion".

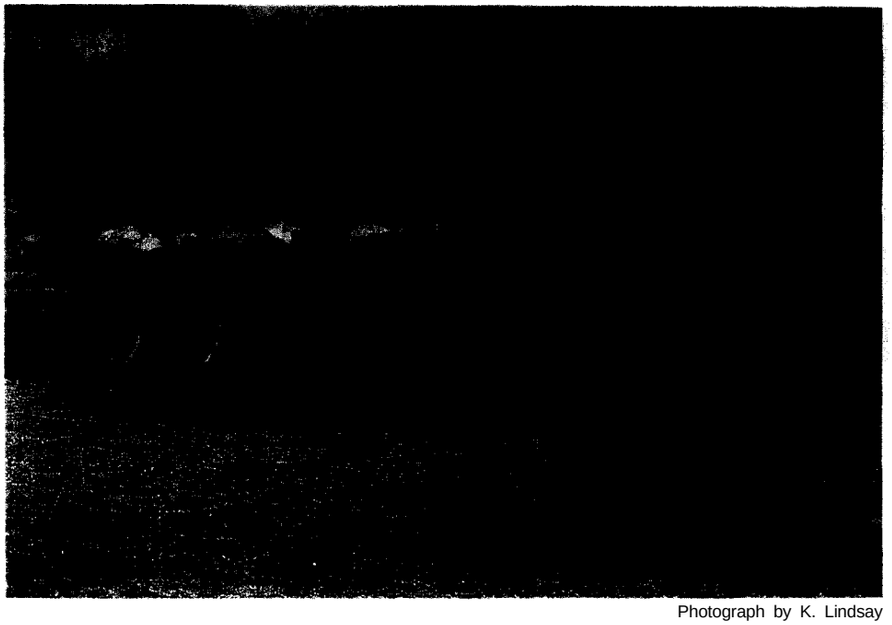
The problems and challenges

The continuing declines expose grave flaws in existing conservation practices and pose a new challenge for species management.

For a start, we can no longer be sanguine about saving species by trade regulations. CITES (The Convention on International Trade in Endangered Species) prohibits all trade in rhino horn and virtually all non-signatory nations have imposed similar bans, to no avail. Substitute products, such as water buffalo and saiga antelope horn, have also been promoted, again with no discernible let-up on rhino losses. The markets, fuelled by ancient practices, are thriving, diffuse, and often clandestine.

Trade regulations are also failing to save elephants. About 80% of the ivory traded between CITES nations is poached and legalized by African governments in need of hard currency'. Eight hundred tonnes of ivory, equivalent to 70 000 or more elephants -twice the annual recruitment – flow onto the world markets each year*, depite a voluntary quota system under which African governments ostensibly set exports at sustainable levels.

If ivory were exploited sustainably,



Photograph by K. Lindsay

the highest profits would accrue from natural mortality, simply because ivory production increases exponentially with age and because price per kilo increases with weight[12]. But sustainable yield is not in the poacher's interests. He cares about immediate maximum profit, knowing that others who can ill afford to await the animal's death are likely to kill it first.

The ivory demand is unsustainable. Exports must halve to stabilize elephant numbers. That is possible only with the full cooperation of all ivory trading nations through an institution like the International Whaling Commission. Yet, not even IWC has fully enforced bans or quotas, and monitoring a few dozen whaling ships and their cargo is trivial compared to keeping track of thousands of poachers and traders throughout Africa, and millions of ivory ornaments worldwide.

Saving pachyderms *in* situ is just as daunting. The cost and logistics of defeating poachers is beyond most African states. Consider the odds: a single big tusker is worth $5000 retail; the average per capita income in Africa is less than $300; and each ranger must patrol 250 km^2 of bush, usually on foot, generally against superior forces. The incentives and advantage rest heavily with the poacher. Not surprisingly, the big remote parks have lost rhinos and elephants faster than small closely patrolled parks. In the Zambezi Valley in Zimbabwe, where the largest population of 750 rhinos survives in thousands of square kilometers, over 250 have been poached in the last 18 months, despite paramilitary operations that have killed 23 poachers and arrested dozens more[4]. In contrast, Kenya's 115 km^2 Nairobi National Park on the city outskirts has held its 35 rhinos for 20 years.

The pachyderm crisis makes two points clear. First, neither trade nor anti-poaching measures are working. Valuable species are vulnerable to poor peoples, many of whom were evicted from parks and denied any use of wildlife. Second, it is harder to save elephants, rhinos and other commercial species in big parks than small. Recognition of these points is bringing about a reappraisal of how to save Africa's threatened species.

Many African governments are facing the human issues by asking how wildlife can benefit rural populations, and how local communities can take part in decisions about saving and using wildlife that directly affect them[13]. In a sense, this is a return to traditional practices, but with added controls on ownership and use. Both in Kenya, where some local communities benefit from tourism, and in Zimbabwe, where ranchers earn sizeable sums from hunting, the 'people approach' is winning support for conservation.

In yet another turnaround, conservationists, in accepting the futility of saving all wildlife, have begun to focus on the essential and the possible: saving a viable set of populations. If choosing such populations signals a new pragmatism, it also raises a suite of problems alien to field managers, but all too familiar to zoo biologists. What populations, or evolutionary significant units, should be secured to give adequate genetic, ecological and geographical coverage of the species[14]? What minimum viable population sizes (MVPs) in the wild are needed to circumvent inbreeding depression, stochastic extinctions and behavioral disruptions's? When should one merge populations, and when should one keep them apart to avoid outbreeding depression or loss of adaptive genotypes? How can one move animals easily, quickly and safely? Nailing down objective criteria is tricky when the taxonomy, genetics, ecology and behavior is as poorly resolved as it is for rhinos, and when we have little idea about effective population sizes and genealogies on which to calculate MVP. Furthermore, these criteria must be modified for wild populations when the objective is to sustain natural selection, rather than maximize genetic diversity, as in endangered species management in captivity.

Weighing urgency against accuracy in its May 1987 annual meeting,

Photograph by K. Lindsay

the AERSG (African Elephant and Rhino Specialist Group of IUCN) identified 30 populations totalling some 200000 elephants and 2500 rhinos. This followed a preliminary review of biological data, including taxonomic reappraisal of rhinos based on craniometric and protein electrophoretic studes[4]. Selection criteria included population size (actual and potential), protectability, uniqueness (genetic and ecological), geographic range, habitat coverage and the overall biological importance of the ecosystem. So, for example, despite seven classified subspecies[16], the preliminary craniometric and genetic analyses found little variation in black rhinos. Nonetheless, three populations, including the arid-adapted Namibian desert rhinos, have been selected for separate management on the basis of ecological and biogeographic criteria. The largest remaining natural populations in Zimbabwe are considered top conservation priority.

Such biological issues are especially germane to black rhinos, which survive in small, isolated groups (Fig. 2). In Kenya the safety of areas such as Nairobi National Park has prompted a national plan to save the last 500 or so animals[3]. Isolated, vulnerable animals are being moved to special rhino sanctuaries. Many, like Nakuru, which will hold 50 or more rhinos in 140 km*, will be ringed by a high-voltage solar fence. The plan is paying dividends already – Kenya's rhinos have stabilized and perhaps increased in the last year. If the method seems drastic, a reminder that a similar plan brought the southern white rhino back from near extinction should be some consolation. Kenya will hold a workshop in March to consider how to adapt the principles of small population management to its beleaguered rhinos.

Though elephants are a couple of decades short of the rhino's predicament, they already pose another thorny dilemma. By crowding into well-protected parks, elephants soon turn woodlands to shrub and grasslands[17]. Biological diversity, a prime objective of national parks, is sacrificed in the process. Should elephant numbers be held down to protect other species, including rhinos? The answer calls for clearly stated policies about ecosystem and species management[17]. Either way, the elephant and rhino crisis is causing prudent species management to replace the laissez-faire ecosystem protectionism that has been possible in Africa until now.

With any luck, the rhino horn trade will shortly dry up from lack of supply. If so, there is plenty of habitat for population recovery. And if that happens soon enough, rhinos may, given their long generation time, yet recover none the worse from a bottle-neck. Meanwhile, we need to explore new conservation approaches and apply biological wisdom in looking after the evolutionary interests of pachyderms and other threatened species.

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Introductions to Animal Behaviour

Animal Behaviour: A Concise Introduction

by Mark Ridley, *Blackwell Scientific Publications, 1986. £8.80 (vi + 210 pages) ISBN 0 632 07416 4*

An Introduction to Behavioural Ecology (2nd edn)

by J.R. Krebs and N.B. Davies, *Blackwell Scientific Publications, 1987. f26.25 hbk, f12.80 pbk (ix + 389 pages) ISBN 0 632 01498 9*

Understanding why animals behave in the varied ways they do remains one of the most absorbing mysteries of biology. Whereas some species live in groups, others live alone; and of those that are social, in some (such as ants) individuals make extraordinary sacrifices to help neighbors, whereas in others (such as gulls) individuals routinely take advantage of each other. Often mating is preceded by lengthy courtship and followed by protracted periods of guarding, but at other times it is a 'hit and run'affair. In some situations it appears that animals tell the truth when communicating, whereas in others fibbing seems to manipulate others into doing things that benefit the deceivers.

What makes the study of animal behaviour so fascinating is that there are different ways of answering the question 'Why?'. The two approaches that have proved to be most useful focus on causation and function. A gull may stretch its neck and coo while courting because particular neural impulses trigger certain muscles to contract in a specific sequence. Such an answer is about causation and treats the animal as a machine whose mechanisms for producing behaviour must be unravelled. Alternatively, a gull may court in a particular way to make sure that a mate is of the right species, or to occupy so much time that philandering by its partner becomes impossible, or even to assess whether a mate has the 'right stuff' to act as a good parent. Answers of this kind are concerned with the adaptive function or survival of behaviour, and are independent of any particular mechanism. Both types of answer are correct and both must exist before a complete understanding emerges as to why a particular behaviour takes the form it does.

The two new introductory texts, by Mark Ridley and by John Krebs and Nick Davies, do excellent jobs of examining both facets of the question 'Why?'. First-time students of behaviour will come away with an appreciation of each approach by reading either book, yet each volume is unique. Whereas *Animal Behaviour* unravels both the mechanisms and functions of animal actions,