Is Dehorning African Rhinos Worthwhile?

E.J. Milner-Gulland[1], N. Leader-Williams[2] and J.R. Beddington[3]

[1] Ecosystems Analysis and Management Group, Department of Biological Sciences, University of Warwick, Coventry, CV4 7AL, UK
[2] Department of Wildlife, P.O. Box 63150, Dar es Salaam, Tanzania
[3] Renewable Resources Assessment Group, Imperial College, 8 Princes Gardens, London SW7 1NA, UK

INTRODUCTION

We have recently developed a simple model for the growth of rhino horn, which was used to analyze the efficacy of rhino dehorning in preventing poaching, and its potential profitability if there were to be a legal horn trade (Milner-Gulland, Beddington & Leader-Williams 1992). The model requires data on the growth rate of rhino horns before and after dehorning, and on the cost-price ratios (ratio between the cost of killing a rhino and the price obtainable for its horn) of harvesters, whether they be poachers or managers. The results of the model must be interpreted taking into account any mortality occurring during dehorning operations. Using the best available data at the time, we concluded that dehorning had to be carried out annually to deter poaching, and that although this dehorning rate could produce near-maximal profits, it would not be sustainable, due to the mortality incurred during the dehorning process. Given that rhino horn cannot at present be sold legally, the point was made that dehorning must be considered as a crisis anti-poaching measure like any other, and its benefits assessed in terms of the reductions in rhino deaths per dollar spent.

Dehorning exercises have now been carried out in Namibia, Zimbabwe and Swaziland, and in June 1992, dehorning became a national conservation policy objective in Zimbabwe. It is planned that all Zimbabwe's rhinos will be dehorned in due course (Milliken, Nowell & Thomsen, 1993). Therefore, since the publication of the model, further data have been collected on all the parameters mentioned above (Table 1), and here we recalculate the results of the model in the light of these data. We conclude that neither the profitability nor effectiveness of dehorning as an anti-poaching measure can be assessed accurately, since the data are too disparate and patchy for generalizations to be made. However, the model, as presented in this paper, can be used for predicting the outcome of future dehorning operations when further data become available, and in assisting decision-making in relation to operations presently underway. The recent loss in early to mid 1993 of the white rhinos experimentally dehorned in Hwange National Park in Zimbabwe in November 1991 makes a re-examination of the issue of dehorning particularly timely and urgent.

THE NEW DATA

i) MortalIty

The mortality rate associated with dehorning does not affect the results of our model (Milner-Gulland *et* al). 1992), but is only used in the interpretation of the results. Unfortunately, this point has been

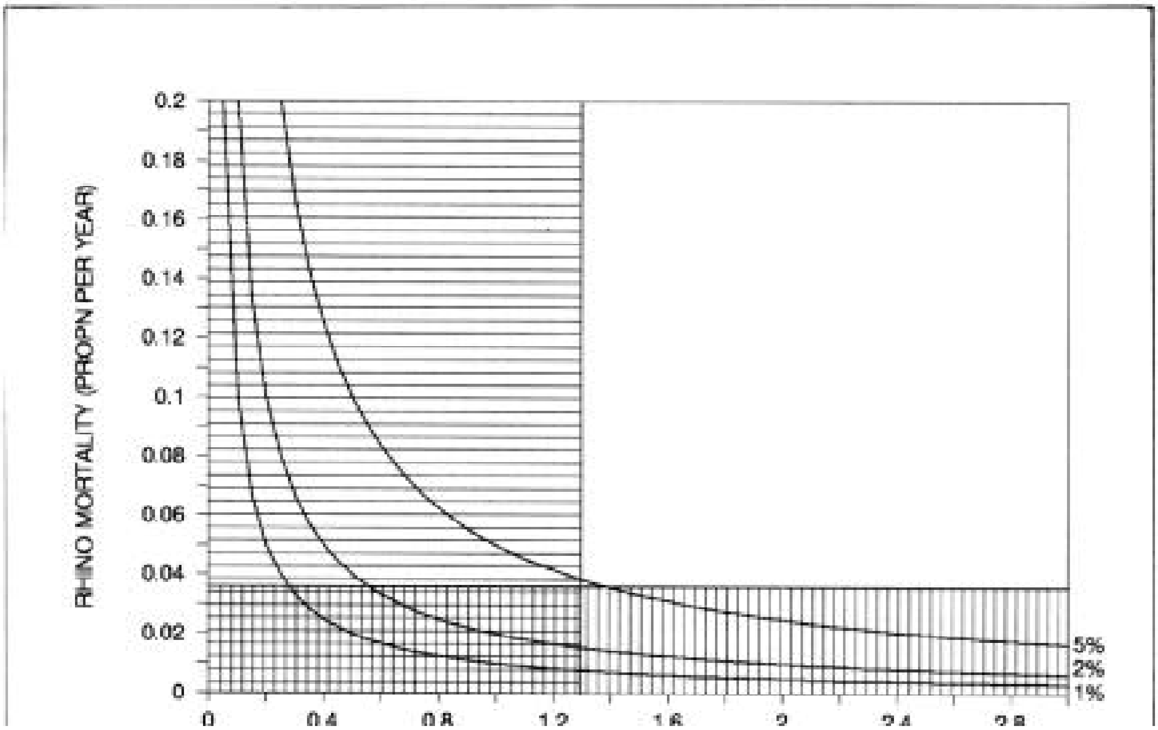
Table 1. Data on rhino dehorning.

Source	Manager			Poacher	
	Dehorning costs (per rhino)	Horn price (per kg)	Associated mortality (%)	Horn price (per horn)	Poaching costs (per rhino)
Milner-Gulland et al. (1992)	$960	$750	9%	Cost-price ratio = 1.2	
Milliken etal. (1993)	$350-$1 ,800		<2%	$100-$360	
R.B. Martin, pers. comm. Kock & Atkinson (1993)	$500	$2,000	1%		
J. Berger (1993)	$1,400			$1 ,775-$7,750 (after 1yr growth)	
Morkel & Geldenhuys 1993	$1,500		0%		

misunderstood by some who have suggested that the predictions of the model are actually affected by the mortality rates associated with dehorning (Milliken et al). 1993). Rhino mortality from dehorning and poaching combined must not exceed 3.7% per annum if dehorning is to be sustainable as a longterm strategy (Milner-Gulland 1991). However, in discussing the results of our original model we assumed that as many as 9% of rhinos could die as a consequence of the dehorning process, based on mortality rates associated with trans-location in the 1960s (Roth & Child 1968). Accordingly, we concluded that dehorning as a longterm strategy would not be sustainable.

Because more recently published data are now available based on the actual dehorning operations (Morkel & Geldenhuys 1993; Kock & Atkinson 1993; Milliken *et al.* 1993), it is clear that a dehorning-associated mortality of 9% is much too high, since both technology and experience have improved. Mortality rates associated with dehorning are now less than 2%, and even as low as 0% (Table 1). Assuming that there is no other human-induced mortality operating, for example that poaching has been completely halted, then with these recent low dehorning mortalities, dehorning might be sustainable as an anti-poaching measure (Figure 1). If the mortality associated with dehorning were only 1%, then 3 dehornings a year could be carried out sustainably, whereas at 9% mortality, dehorning could only be carried out every 2.5 years to be sustainable. As dehorning changes from a once-off crisis response to poaching onslaughts, as it was when first practised in Namibia, to an institutionalised activity that authorities aim to carry out regularly, as is now the policy in

Figure 1. The relationship between rhino mortality and dehorning rotation time. Sustainable human-induced mortality rates and rotation times that will deter poaching are shown as shaded areas - where they overlap, dehorning is both sustainable and a deterrent. Contours are drawn on for dehorning mortality rates of 1%-5%. The rotation times for which dehorning is both sustainable and deterrent can be read off for a given dehorning mortality rate as the times for which the contour is in the double-shaded box. Thus dehorning at a mortality rate of 5% is never both sustainable and a deterrent, whereas at a mortality rate of 1%, dehorning is both sustainable and a deterrent at rotations of 0.3-1.3 years.



Zimbabwe, it is important that this point is recognised in relation to our earlier conclusions (Milner-Gulland et *al*. 1992).

ii) Horn growth rate

When the model was produced, very few data were available on horn growth rates, either after dehorning or on a young animal. For that reason, a function for horn growth was assumed, which gave smooth growth to a maximum horn weight of 3kg, slowing as horn weight neared the maximum. Horn growth rate was assumed to be identical for a dehorned rhino as for a young rhino, and not to vary with age or sex of the rhino. The horns of dehorned rhinos have been observed to grow back rapidly and without deformity, reaching slightly less than full size after three years (Berger 1993). In general, the results of our model are not sensitive to the rate of horn regrowth assumed, particularly if regrowth is faster than is assumed in the model (Milner-Gulland et *al.* 1992). Data are not yet adequate to determine the functional form of horn regrowth, so the form of horn regrowth assumed in the model was not changed.

iii) Cost price ratios

The ratio between the cost of killing a rhino and the price obtained for its horn is clearly key to the profitability of hunting for the poacher, and of dehorning for the manager. The cost-price ratio is extremely hard to estimate for poachers, and will vary depending on whether the poacher is in an organised gang or is more opportunistic, as well as with the economic situation of the country from which the horn is exported (Milner-Gulland & Leader-Williams 1992). Thus large disparities appear between the poacher prices of rhino horn reported by Berger (1993) and Milliken et *al.* (1993) (Table 1). There are no new data on the costs of poaching. Therefore, the poacher cost-price ratio assumed in Milner-Gulland et a). (1992) is retained here, since the costs and prices assumed in this ratio are internally consistent. The ratio was calculated for the Luangwa Valley, Zambia, in 1985, and so is rather out of date and is for a country that has not carried out dehorning. Data on poacher costs and prices are crucial to an accurate assessment of the time after dehorning at which a rhino will be susceptible to poaching, and so need urgent attention. These data should include, for a particular area: the price obtained by the poacher and middleman for the horn; the costs of mounting a poaching expedition, including paying the gang members; the probability that a gang member will be captured, and the penalty he is likely to face if caught; and the number of trophies that are captured on each hunting expedition (depending on the length of the expedition, the density of the prey population, weapon efficiency, and visibility of the prey).

Since several dehorning exercises have now taken place, the costs of dehorning to a manager are now better known (Table 1). However, the reported costs vary between US$350 and US$1800 per rhino, depending on the rhino species, density and the terrain. The price per kg of horn obtained by a manager was assumed in the previous paper to be US$750, but R.B. Martin (pers. comm.) states that the prices being negotiated at present for horn from dehorning exercises are in the region of US $2000/ kg. These data produce cost-price ratios for profitmaximising managers that range between 0.18 (350/ 2000) and 2.4 (1800/750), which is a very large range of possible ratios. Perhaps the most likely ratio to be correct, that expected by the Zimbabwe government, is around 0.25 (R.B. Martin, pers. comm.). The optimal rotation times for managers to maximise their profit, and the rotations on which a rhino must be dehorned to prevent poaching, were calculated for a range of cost-price ratios (Figure 2). The poachers' cost-price ratio leads to the rhino being poached 1 .3 years after dehorning, substantially earlier than the lowest optimal rotation time for a profit maximising manager of 1.7. The new data on the costs of dehorning therefore do not substantially alter the conclusion of our earlier paper, that a rhino will be killed by a poacher before the profit-maximising manager dehorns it, and that annual dehorning is necessary to prevent poaching. If further data on cost-price ratios are received, the resulting optimal rotation or killing time can simply be read off the graph in Figure 2.

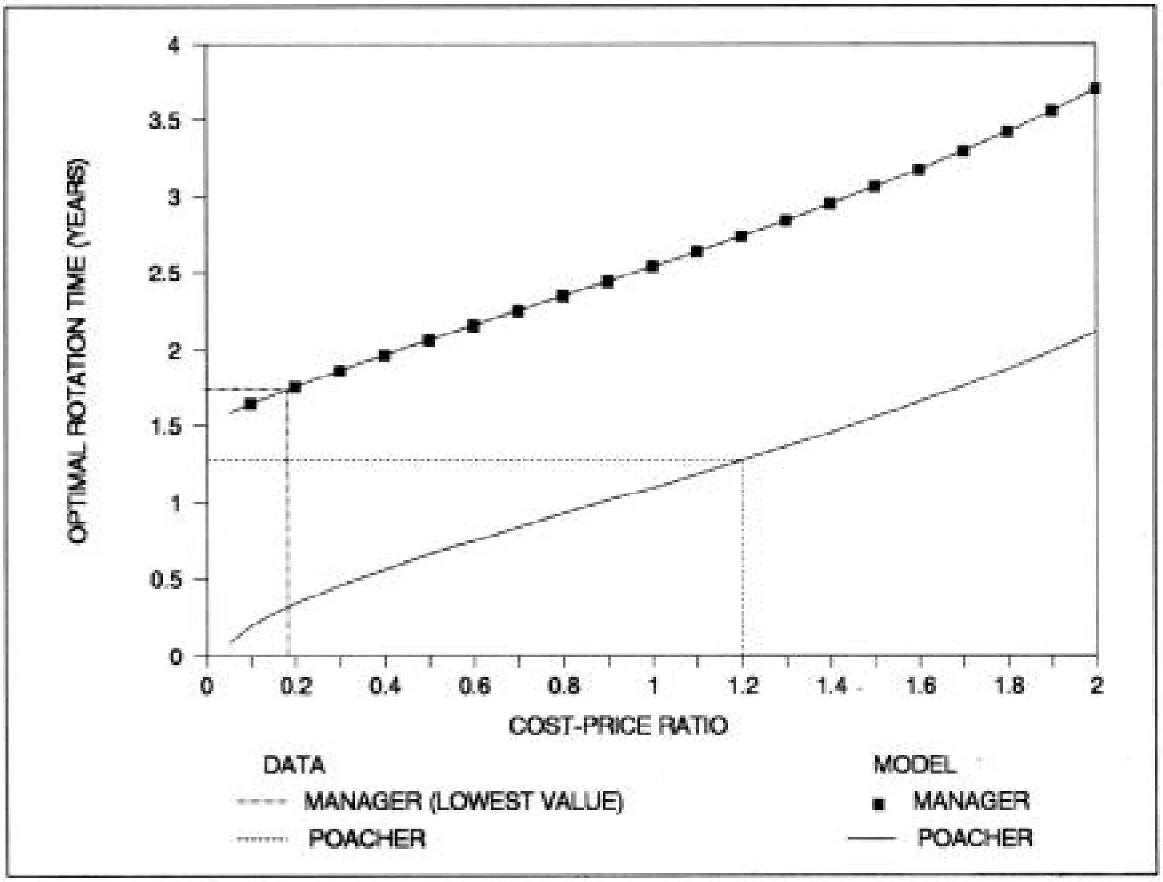
These results can also be interpreted in terms of the present value of the lifetime supply of horn from a rhino at birth, which is the sum of profits from dehorning throughout the rhino's life, but with the profits in the distant future reduced using the discount rate, which represents the fact that income in the distant future is worth less than income today. The rhino is assumed to live for 40 years, and to be dehorned at the same interval throughout its life. The present value of a rhino will depend on the manager's cost-price ratio and discount rate, and on the mortality rate associated with dehorning. It is worthwhile to consider profits to be made from dehorning despite the fact that horn cannot be traded legally, because the debate on whether to reopen trade in rhino horn continues, and has been fuelled by the growth in stocks of horn from dehorned rhinos.

Our model can help to give an idea of the potential profitability of dehorning if the trade reopened, and thus inform the debate.

Figure 3 shows the present value of a rhino at various dehorning rotation times, for a range of cost-price ratios from the data in Table 1. The present values are shown as percentages of the maximum present value at the optimal rotation rate for a particular cost-price ratio. Thus at a cost-price ratio of 0.2, the optimal rotation time is about 1.8 years (Figure 2), which is when the present value is 100% of maximum. At rotation times lower than optimal, the present value drops rapidly, and soon becomes negative, since the costs of dehorning outweigh the revenues from the small amount of horn obtained at each dehorning. At rotation times longer than optimal, the present value decreases gradually because longer rotation periods reduce the total number of rotations possible, even though the amount of horn obtained per dehorning may be larger than at the optimum. As the cost-price ratio increases, the optimum rotation time and the break-even rotation time become longer, as dehorning becomes more expensive. The curves are all scaled to 100% at the maximum present value, for the sake of clarity. Although it is not shown in Figure 3 because of the rescaling, the maximum present value also gets smaller as the cost-price ratio increases and dehorning gets more expensive.

A line on Figure 3 shows the rotation time of 1.3 years needed to deter poachers. The profits gained by a manager who dehorns at this time depend on his cost-price ratio. If it is 0.2, then profits are 98% of the maximum, while at a cost-price ratio of 1.4, a

Figure 2. Changes in optimal rotation time and optimal poaching time as coat-price ratios vary, for a poacher (solid line) and a profit-maximising manager (squares). Details of the calculations are in Milner-Gulland et al. (1992). The lowest optimal rotation time for a profit-maximising manager is shown (dot-dashed line), together with the optimal time for a poacher to kill a rhino (dashed line), both from Table 1. The lowest optimal rotation time for a profit-maximising manager is significantly higher than the poacher's optimal poaching time, despite the manager's cost-price ratio being much lower than the poacher's, so the rhino will be killed by a poacher before a profit-maximising manager would dehorn it.

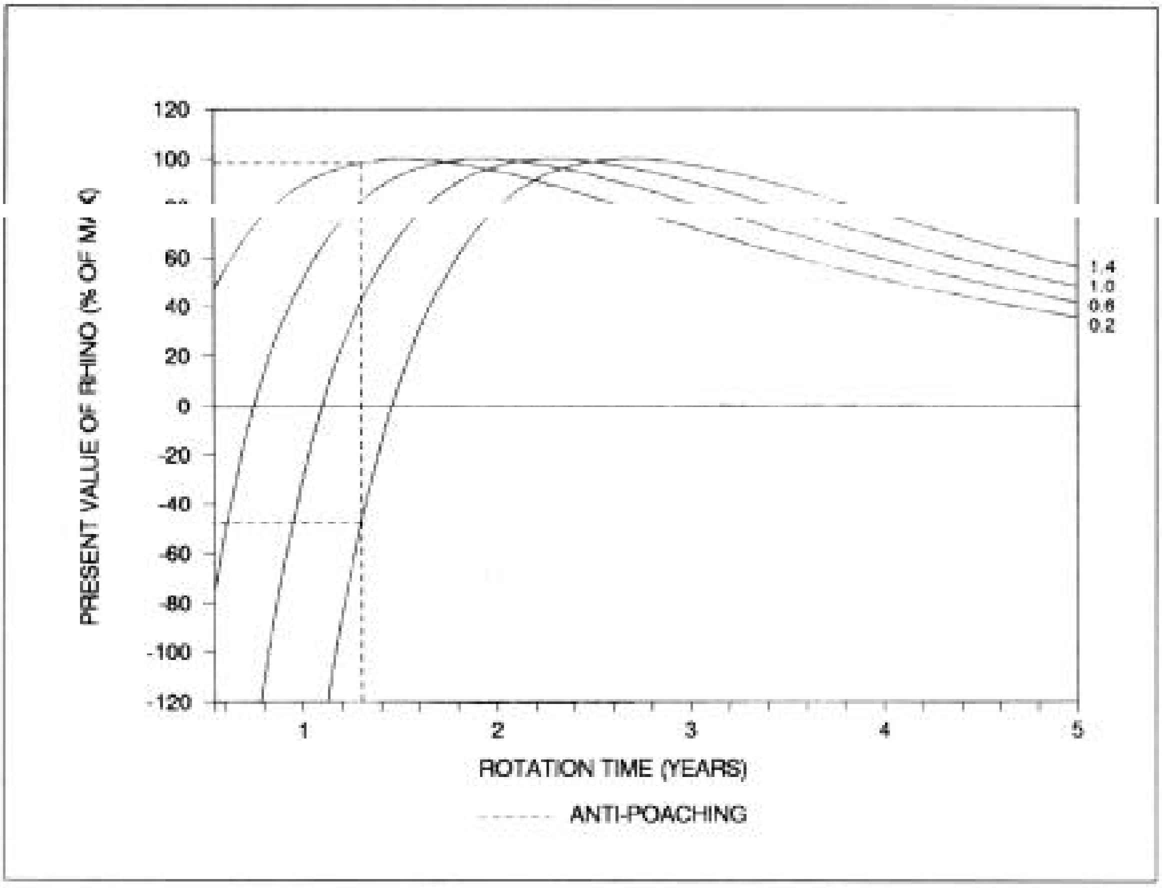


loss would be made. The data in Table 1 give cost-price ratios of 0.18-2.4, so the potential profitability of dehorning as an anti-poaching measure will vary with the circumstances. However, it should be noted that the losses associated with high cost-price ratios are less than the gains associated with low cost-price ratios, since the maximum profits to which losses are scaled are lower at high cost-price ratios. So if the cost of dehorning a rhino is assumed to be US$500, then dehorning to prevent poaching leads to a present value of a lifetime s supply of horn of US$5,350/rhino at a cost-price ratio of 0.2, or -US$130/rhino at a cost-price ratio of 1.4. By comparison, a common rule of thumb is that $200/km^2/year was needed effectively to control poaching in protected areas in 1980, which translates to $500/rhino/year at a rhino density of 0.4/km^2 (Leader-Williams, 1990).

DISCUSSION

The conclusions to our original paper (MilnerGulland et *al.* 1992) were that there were three possible intervals at which a manager might dehorn rhinos, depending on his objectives. At present, rhino dehorning is used only as a crisis anti-poaching measure, and as such, dehorning needs to be done as soon as the horn has regrown sufficiently for it to be profitable for a poacher to hunt the rhino. The data suggest that annual dehorning would be necessary to fulfill this objective. If a manager wished to exploit rhinos commercially by removing and then selling horn, either on a ranch or to fund rhino conservation, and assuming the horn could be sold legally, the rhino would be dehorned at the profit-maximising rotation period, calculated as once every two years.

Figure 3. The present value of a rhino at birth depending on the dehorning rotation rate, assuming that the manager has a discount rate of 0.3, and the rhino will be dehorned at the same interval throughout its 40-year lifespan. The manager is assumed to be dehorning at a sustainable rate, with a dehorning-induced mortality rate of 2%. Results are shown for cost-price ratios of 0.2-1.4, scaled to the maximum present value at the optimal rotation time. The present value of a rhino dehorned at the rotation time necessary to prevent poaching is shown (dashed line).



Finally, assuming a mortality rate of 9% associated with dehorning, the population would decline under any rotation less than 2.5 years due to the extra mortality caused by dehorning. It was concluded that a conservation measure that caused a population to decline was not practical in the long run (although in the short run it might still reduce the rate of population decline more than any other available measure). Therefore, a pessimistic note was struck about the likely success of dehorning as a conservation measure, although it was noted that if poaching could be stopped by other means, conservation could perhaps be funded by sustainable dehorning.

Since the paper was published, the results of the first dehorning exercises have appeared, and so the model has been recalculated using data from these exercises. Several new conclusions can be reached:

1. The mortality associated with the dehorning operation is now substantially lower than was assumed in discussing the results of the model. This means that the sustainable rotation period is shorter than that needed to deter poachers, and so loses its importance as a determinant of the usefulness of dehorning as a conservation measure.

2. The data on horn regrowth rates are scanty, and neither justify nor contradict the assumptions made in the model. More data are needed on this parameter, especially on the functional form of horn regrowth, which is particularly important for the validity of the model. Sensitivity analyses have shown that the effects of changes in the rate of horn regrowth are less likely to have a major effect on the results than changes in the functional form for regrowth.

3. There are few up-to-date data on horn prices received by poachers, and none on the costs of poaching, for the countries where dehorning has taken place, or may soon take place. The poacher's cost-price ratio is the crucial determinant of the interval between dehornings, since mortality during dehorning is less important. The data used here for the poacher's cost-price ratio are still the best available, despite being for the Luangwa Valley, Zambia, in 1985. This lack of data on the costs of poaching must be rectified if a rational programme of dehorning for control of poaching is to become a major part of the rhino conservation effort.

4. The costs of dehorning to managers are the best documented data, but the costs vary in magnitude by a factor of five. The price of horn to managers has been estimated twice, but must remain unclear until there is a realistic possibility of a legal horn market. The manager's cost-price ratio could therefore take a large range of values, and so could the potential profitability of dehorning and selling the horn. It is impossible to tell at this stage whether dehorning could cover the conservation budget of a country or be a drain on resources. Partly this depends on whether dehorning is used as a method of deterring poaching as well as generating money, or whether it is carried out on a secure population of rhinos.

5. The data still suggest that dehorning as an anti-poaching measure must always be carried out sooner than would be optimal for a profit-maximising manager. The low mortality associated with dehorning, and the apparent, although thinly documented, success of dehorning in preventing poaching over the last three years (Milliken et *al*. 1993) might have led us to be more hopeful about the future of dehorning as a sustainable conservation strategy. Indeed, results from black rhinos in Zimbabwe remain encouraging in that only 14 or 15 rhinos have been poached out of a total of around 210 dehorned (Milliken pers. comm.). However, the loss of most of Hwange's dehorned white rhinos in early to mid 1993 may raise further concerns over the decision to dehorn. At least two factors may have come into play here: the rotation period between dehornings and the lack of protection for dehorned rhinos.

In relation to the first factor, our own model suggests that rhinos need to be dehorned every 1.3 years to deter poachers (Figure 2), and most of the Hwange white rhinos had been dehorned slightly longer ago than this when they were killed. Therefore, one possible implication from our model is that the horns had already grown enough to be attractive to poachers, and indeed many of their horn bases and regrown stumps had been removed by the poachers. Other explanations that have been advanced include that having tracked a rhino, only to find it dehorned, poachers kill it so as not to waste time in future following its tracks (Milliken pers. comm.); and that there may be interest among speculators in exterminating all rhinos, dehorned or not, in order to increase the value of illegally held stockpiles (Kock & Atkinson 1993).

The second main factor is that Zimbabwe has been through a funding crisis in which the Department of National Parks and Wild Life Management budget has been cut, and anti-poaching patrols ceased during early to mid 1993 in Hwange, thereby providing dehorned rhinos with no protection and so reducing the costs of poaching. Without further information, it will probably not be possible to determine the extent to which these various factors were responsible, alone or in combination, for the extensive loss of these dehorned white rhinos in Hwange.

In conclusion, it appears clear that while dehorning mortality is less of a concern than we had originally assumed, other factors, such as the optimal rotation times between dehornings and continuing to provide adequate protection, will remain important considerations in determining whether dehorning is likely to succeed as a measure that will contribute to the successful conservation of African rhinos presently facing an onslaught of poaching in southern Africa.

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ACKNOWLEDG EMENTS

We thank Rowan Martin, Tom Milliken and Teresa Mulliken for communicating recent data from Zimbabwe.