

**Policies for the Enforcement of Wildlife Laws: The Balance between
Detection and Penalties in Luangwa Valley, Zambia**



N. Leader-Williams; E. J. Milner-Gulland

Conservation Biology, Vol. 7, No. 3 (Sep., 1993), 611-617.

Stable URL:

<http://links.jstor.org/sici?sici=0888-8892%28199309%297%3A3%3C611%3APFTEOW%3E2.0.CO%3B2-J>

Conservation Biology is currently published by Blackwell Science, Inc..

Your use of the JSTOR archive indicates your acceptance of JSTOR's Terms and Conditions of Use, available at <http://uk.jstor.org/about/terms.html>. JSTOR's Terms and Conditions of Use provides, in part, that unless you have obtained prior permission, you may not download an entire issue of a journal or multiple copies of articles, and you may use content in the JSTOR archive only for your personal, non-commercial use.

Please contact the publisher regarding any further use of this work. Publisher contact information may be obtained at <http://uk.jstor.org/journals/blacksci-inc.html>.

Each copy of any part of a JSTOR transmission must contain the same copyright notice that appears on the screen or printed page of such transmission.

JSTOR is an independent not-for-profit organization dedicated to creating and preserving a digital archive of scholarly journals. For more information regarding JSTOR, please contact support@jstor.org.

Policies for the Enforcement of Wildlife Laws: The Balance between Detection and Penalties in Luangwa Valley, Zambia

N. LEADER-WILLIAMS*

Large Animal Research Group
Department of Zoology
Downing Street
Cambridge CB2 3EJ
United Kingdom

E. J. MILNER-GULLAND†

Renewable Resources Assessment Group
Imperial College
8 Princes Gardens
London SW7 1NA
United Kingdom

Abstract: *Models have shown that levels of law enforcement in Luangwa Valley, Zambia, during the 1980s were not adequate to prevent illegal exploitation of black rhinos and African elephants. Theory suggests that the deterrent effect of an increase in detection rate will be larger than that of a similar increase in penalty. The most effective penalty, in economic terms, would be a variable fine related to the number of illegal trophies harvested, but this may be hard to legislate effectively. Wildlife managers conserving rhinos and elephants should focus on improving detection rates rather than on requesting severe penalties with no improvements in detection.*

Políticas para el cumplimiento de leyes sobre vida silvestre: Balance entre detección y penalidades en el valle de Luangwa, Zambia

Resumen: *Los modelos han demostrado que los niveles de cumplimiento de la ley en el valle de Luangwa, Zambia, durante los años 1980s no fueron adecuados para prevenir la explotación ilegal de rinocerontes negros y elefantes africanos. La teoría sugiere que los efectos disuasivos de un incremento en la tasa de detección podrían ser mayores que aquellos de un similar incremento en penalidad. La penalidad más efectiva, en términos económicos, sería una multa variable en relación al número de trofeos ilegales recolectados, pero esta medida resulta difícil de legislar efectivamente. Aquellos que se dedican al manejo de la vida silvestre para la conservación de los rinocerontes y elefantes deberían concentrarse en mejorar las tasas de detección en lugar de solicitar severas penas sin mejoras en la detección.*

*Present address: Department of Wildlife, P.O. Box 63150, Dar es Salaam, Tanzania

†Present address: New College, Oxford, OX1 3BN, U.K. (All correspondence to this author.)

Paper submitted June 17, 1992; revised manuscript accepted February 9, 1993.

Introduction

The loss of Africa's and Asia's rhinos and elephants to supply world markets in ivory and rhino horn has resulted in the institution of a longstanding ban (since

1977) on trade in rhino horn and a more recent ban (1989) on ivory (ITRG 1989; Western 1989). There is increasing recognition of the importance of investing in protected areas to control illegal supply to these markets (Leader-Williams & Albon 1988, Parker & Graham 1989). This involves determining how best to invest limited funds to deter illegal exploitation of wildlife resources. In this paper, we evaluate the policy implications of various strategies to deter poaching. We conclude that more emphasis should be placed on improving detection rates than on imposing heavy penalties.

Economic Incentives to Crime and Wildlife Laws

Studies on theft and burglary in the U.S. suggest that incentives to crime are reduced if there is (1) an increase in the perceived probability or severity of punishment, (2) a decrease in profit from the crime, or (3) an increase in the opportunity cost of the crime through improved wages elsewhere (Cook 1977). The last depends to a large extent on improvements in the national economic climate, but law enforcement agencies can affect incentives in the first two ways. The probability of

being caught and convicted (strictly two separate factors, but usually combined) has been found to be a strong deterrent to crime. Opinion is divided on whether the severity of a sentence has any deterrent effect, but studies agree that the penalty level is less of a deterrent than the detection rate (Ehrlich 1973; Avio & Clark 1978). This result contradicts the intuitively optimal policy for the deterrence of crime, which is to maximize the penalty, if this is costless to the state, and minimize the money spent on law enforcement.

Prison and fines are commonly used to deter illegal exploitation of wildlife in Africa (IUCN 1986; Table 1). Fines are arguably a better form of penalty than prison sentences, since they act as a "tax" on illegal activity and as a direct transfer payment from offender to victim, in this case the state, which has lost a valuable animal (Becker 1968). Fines have the further advantage of being cheaper to administer than prison sentences. Prison sentences incur large costs, both to the state and the prisoner, whose future legitimate earning power may be seriously compromised. An offender's a priori perception of the severity of a prison sentence will depend on his discount rate and time horizon—how much he values the present over the future and how far into the future he looks. If someone is indifferent between the

Table 1. Changes in laws of different countries as they relate to poaching of elephants and rhinos.

Country	Species	Previous laws				Changed laws				Shoot-to-kill
		Year	Fine ¹	Real F	Prison	Year	Fine	Real F	Prison	
Kenya	Elephants Rhinos	1976	<20,000 <40,000	<3790 <7581	<5 <10					1989
Namibia	Elephants and rhinos	1980	6000	8624	6	1990	200,000	38,374	20	
South Africa ²										
NPB	Elephants and rhinos	1980	3000	4312	2	1991	3000–100,000	575–19,187	3–10	
TNCD	Elephants and rhinos	1980	1500–2000	2156–2875	1½–2	1991	100,000	19,187	10	
CDNEC	Elephants and rhinos	1980	3000–6000	4312–8624	1–2	1991	100,000	19,187	10	
OFSDNC	Elephants and rhinos	1980	800	1150	2	1991	100,000	19,817	10	
NaPB	Elephants and rhinos	1980	2000	2875	½	1990	100,000	19,817	10	
Tanzania	Elephants Rhinos	1974	—	—	⅓–30 3–15	1989	—	—	⅓–30 20–30	
Zaire	Elephants and rhinos					1982	5000–50,000	299–2992	<5	1975
Zambia	Elephants and rhinos	1961	2500	38,500	<5	1982	—	—	5–15	
Zimbabwe	Elephants Rhinos	1982	750–1000 1000	1312–1749 1749	1–1½ 1½	1990	1500–2000	499–666	1½–2 5–15	1987
Indonesia	Elephants and rhinos				⅓–10	1987	5 mill	2620	10	
Malaysia	Elephants Rhinos	1972	<3000	<5916	<2	1988	<3000 <15,000	<451 <2255	<2 <5	

¹ Currencies. Actual fines are shown in the local currency: Kenya—shillings; Namibia and South Africa—rands; Zaire—Zaires; Zambia—Kwacha; Zimbabwe—Zimbabwe dollars; Indonesia—rupiah; Malaysia—ringgit.

² Boards in South Africa. NPB—National Parks Board; TNCD—Transvaal Nature Conservation Department; OFSDNC—Orange Free State Department of Nature Conservation; NaPB—Natal Parks Board; CDNEC—Cape Directorate of Nature and Environmental Conservation.

Note: Actual fines are shown in local currencies, and their real values in the year of enactment (Real F) are calculated as \$US in 1985 for comparative purposes. Prison sentences are shown in years, and shoot to kill policies are shown as the year in which they were first declared.

value of the present and the value of the future, an expected prison sentence of 0.2 years can be expressed equally well as a 10% chance of two years in prison or a 20% chance of one year in prison. However, if the value of the future declines as it gets more distant, the second year in prison is valued less than the first year, so one year with a probability of 0.2 is the worse option (Cook 1977). In Africa, the distant future is uncertain and so is valued less highly than the present and immediate future. This suggests that, in Africa, concentrating on increasing detection rates is a better strategy than increasing the length of prison sentences.

It is also appropriate to concentrate on detection rates rather than penalties in Africa because the courts are completely separate from the wildlife authority and do not always set the same priority on protecting wildlife. In Zambia, concern about the loss of elephants and rhinos and about ivory and horn trafficking led the government to introduce mandatory 5–15 year prison sentences for elephant and rhino poachers in 1982. But although magistrates tended to deliver more prison sentences to elephant and rhino offenders, not all received prison sentences after 1982, and they were short, with a maximum length of three years. The legislation to increase penalties was slow and difficult to enact, and it has been incompletely carried out (Leader-Williams et al. 1990). Many range states in both Africa and Asia have responded to the poaching crisis beginning in the 1980s by enacting stiffer penalties, usually longer periods in prison or larger fines, for the illegal exploitation of rhinos and elephants (Table 1). In addition, in certain countries, shoot-to-kill policies have been instituted for killing rhinos (in Zimbabwe, see, Tatham 1988; Tatham & Taylor 1989) or toward those simply for entering a Protected Area (Zaire and Kenya). Zambia, where our case study was carried out, does not operate a shoot-to-kill policy for wildlife crimes (Chapter 316 of the Laws of Zambia; Leader-Williams et al. 1990).

A Case Study: The Luangwa Valley, Zambia

During 1979–1985, anti-poaching patrols in Luangwa Valley, Zambia, kept records of sightings and captures of poachers and the sentences subsequently passed on them (Leader-Williams et al. 1990). These data form the basis of an economic model of incentives for illegal exploitation (Milner-Gulland & Leader-Williams 1992). There are two clear types of poacher encountered. On the one hand, local people undertake subsistence meat hunting, which is a traditional and cultural necessity in an area where domestic stock cannot be herded due to tsetse fly infestation (Marks 1976, 1984). They hunt locally for short periods, using primitive firearms such as muzzle-loading guns as well as spears, snares, and dogs.

Although local people hunt mainly for meat, they will occasionally kill an elephant or rhino both for meat and for a trophy to be sold later to a dealer. On the other hand, organized poaching gangs from outside the Luangwa Valley usually contain two professional elephant and rhino hunters with automatic weapons and/or good rifles and about six carriers. The gang penetrates deep into the national park, stays out for many days, and may be caught with as many as 48 tusks and six rhino horns (Leader-Williams et al. 1990).

Local and organized poachers have very different patterns of incentives. The decision-maker in the local gang is the poacher himself, but in the organized gang the decision-maker is a dealer in contraband. The relatively low hunting costs for the local poacher are offset by (1) inefficient weapons and low elephant and rhino populations in the areas where he hunts; (2) the relatively low value of his trophies because, rather than being employed by a dealer, he has to sell to him directly; and (3) a potential penalty that is high compared to the hunter's low costs and profits. In an organized gang, by contrast, the dealer hires skilled hunters with sophisticated weapons and faces higher costs than the local hunter does. These costs are offset (1) by superior weapons, longer expeditions, and higher densities of prey in national parks, resulting in large numbers of trophies, which can be sold abroad at high prices, and (2) by the fact that the decision-maker himself is rarely caught. The penalties for poaching therefore have less potential effect on the dealer's decision making.

The model showed that elephants and rhinos were scarce enough that the cost of the hunt itself was enough to deter the local poacher from hunting. Even if the price of ivory or horn doubled, it would still not be worth his while to hunt specifically for elephants and rhinos. Thus, law enforcement was relevant only to local hunters inasmuch as it prevented opportunistic killings of elephants and rhinos found when hunting for meat, and as it related to entering national parks in the first place. The opposite situation held for the organized gangs hunting elephants. Only if both hunting costs doubled and the price obtained per kill was reduced five-fold would it be unprofitable for organized gangs to hunt elephants. Law enforcement had virtually no effect on the decision to hunt because the profits from hunting were so much higher than the expected penalties. However, the rhino population was so low in 1985 that it was not profitable to hunt rhinos alone, although if the gang chanced upon one it would have been worth killing it. Thus the model predicts that the rhino population declined due to opportunistic killings by gangs hunting for elephants.

These predictions fit the data well in that organized gangs in Luangwa Valley were caught either with elephant tusks or with tusks and a few horns, while local hunters were usually caught with meat and sometimes

with a few tusks or horns (Milner-Gulland & Leader-Williams 1992). In 1985, there was a larger population of rhinos in the Zambezi Valley, Zimbabwe, and organized gangs did hunt exclusively for rhinos there (Tatham 1988).

Implications for Deterring Local Gangs

Because they are poor, local poachers are likely to be deterred by fines for hunting elephants and rhinos. A prison sentence is a severe penalty because it has a serious effect on the welfare of local hunters' families, most of whom are self-employed hunters and farmers. Local hunters are marginal offenders, for whom the incentives to poach are not great, and so are likely to be easily turned from crime by the threat of a higher penalty (see Thurow 1980). Equally, too severe a penalty could turn a local hunter into a serious elephant and rhino poacher (Stigler 1970).

There is usually a social barrier to illegal activity, which is breached at present because meat hunting is a traditional and cultural necessity in an area infested with tsetse fly where domestic stock cannot be herded (Marks 1976, 1984). If access to wildlife resources were better regulated so that most local meat hunters were not acting illegally, the opportunistic killing of elephants and rhinos would have to be more profitable for the transition to illegal activity to occur. A wildlife authority has the power to increase the opportunity cost of poaching by increasing legitimate earning potential within protected areas. Projects that give some responsibility for management decisions, provide local jobs, and channel some of the proceeds from safari hunting and tourism to local people have been very successful. The ADMAD project in Luangwa Valley has caused a reported drop in illegal activity because poachers are no longer helped or tolerated by locals (Lewis et al. 1990).

Implications for Deterring Organized Gangs

Deterring organized gangs from poaching presents more serious problems. The Zambian economy has declined over the past few decades, particularly in the 1980s, leading to lower wages in real terms, while the price of ivory and rhino horn increased dramatically until the ivory ban of 1989 (Fig. 1). In 1985, a trophy dealer could earn far more than a legitimate wage-earner (Fig. 2). A gang could get 30 kg of ivory per expedition and one rhino in seven expeditions, and would only have been deterred by a probability of detection of 0.9 or a penalty of K20,000 per hunter, rather than the 1985 values of 0.05 and K500 respectively (Milner-Gulland & Leader-Williams 1992). Another problem is that the decision-maker, the dealer, is not himself convicted. Confessions and the sentences delivered to poachers, however, suggest that dealers often bought the acquittal of hunters with small fines, while the more disposable car-

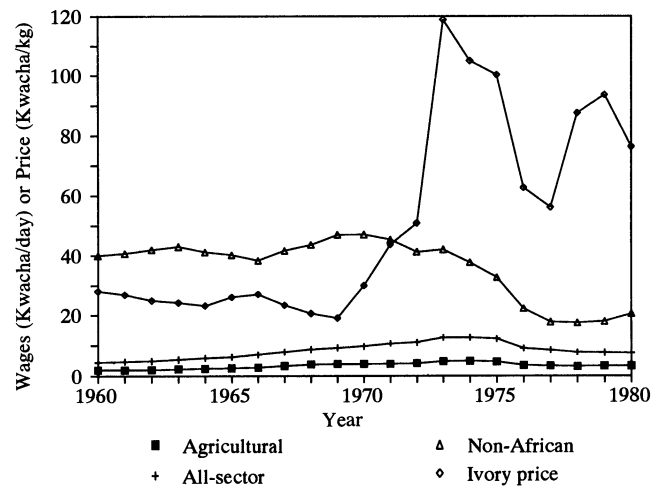


Figure 1. A comparison of real ivory price/kg and real wages/day in Zambia over the period 1960–1980, corrected with a base of 100% in 1980.

riers were sentenced to prison. Therefore, small fines for hunters were just part of the economic equation of ivory and horn trading, suggesting that much higher fines for hunters could have deterred dealers. But fine sizes require careful adjustment because they will be effective only as long as the dealer pays. If fines are too high, they become ineffective because the dealer will allow the hunter to go to prison by default. Equally, giving a prison sentence to an employed hunter probably would not have deterred the dealer from funding poaching until he ran out of skilled hunters. The risk premium needed to attract hunters into organized poaching may, however, increase if the sentences are perceived as severe, particularly if prison is involved.

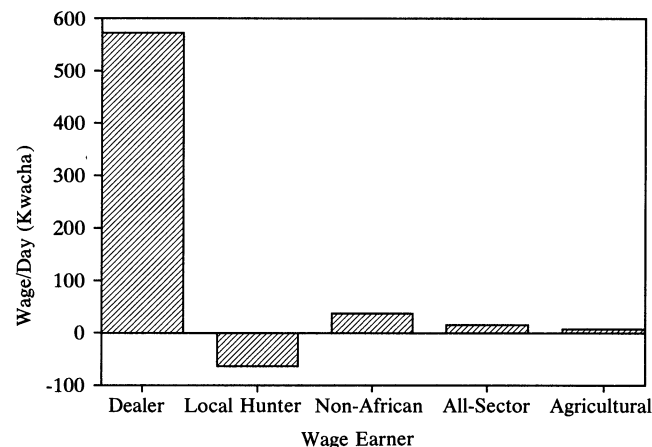


Figure 2. The 1985 wage/day in different sectors of the economy, and the expected wage/day that could be earned by a dealer and a local hunter from ivory. The expectation of a penalty is included in the wages of dealers and hunters (based on data in Milner-Gulland & Leader-Williams 1992).

The ideal solution would be to deliver appropriate sentences to dealers in ivory and rhino horn. This would require more emphasis on intelligence gathering aimed at arresting dealers. Maintaining or increasing the differential between penalties for elephant/rhino hunting and other offences, especially for traffickers and middlemen, is crucial. It may also be desirable to make penalties more severe for possession of rhino horn than of tusks because rhinos are more endangered than elephants. A larger fine for rhinos could also discourage opportunistic rhino killing, although in the Luangwa Valley reducing incentives to hunt elephants should also reduce rhino hunting.

Another option that would dramatically reduce incentives to poach would be to make fines for elephant and rhino offences dependent upon the total number of trophies captured. At present, court records indicate that poachers are penalized only for illegal hunting, not for the number of animals killed. If the fine were proportional to the total number of animals killed, however, then the optimal proportion of the population for the organized hunter to kill could have been reduced from 90% to 2% (Milner-Gulland & Leader-Williams 1992). This also penalizes the poachers who kill the most animals and so do most harm to elephant and rhino populations. But achieving legislation for a variable fine could be difficult, partly due to the time needed for its passage through bureaucratic structures when a swift response to changing price structures and population sizes is necessary, and partly because of the inherent difficulties of administering a flexible system. The final problem with deterring organized gangs is that large increases in real wage rates or decreases in trophy prices abroad may not be within the control of a wildlife authority. Improvement in legitimate earning potential would raise the cost of the hunter to the dealer, but this is hard to achieve because organized gangs are recruited outside the Luangwa Valley, and the national economy is declining (Leader-Williams et al. 1990; Fig. 1). The only chance of increasing the cost of hunting would be to increase the perceived risks, imposing a large risk premium on the dealer. This might be achieved by the wildlife authority in Zambia in two ways: first by imposing the ultimate penalty of a shoot-to-kill policy, with all its implications for justice and human rights, and second by improving the detection rate by an order of magnitude.

Wider Implications: Balancing Penalties and Detection Rates

A questionnaire survey of legislation on offences involving the illegal exploitation of rhinos and elephants produced responses from nine range states, seven in Africa and two in Asia (Table 1). Of these, eight states have

enacted stiffer penalties for poaching rhinos and/or elephants since the poaching crisis first came to world attention in 1980 (Zimbabwe changed its laws in 1985 and 1990, but only the recent change is shown in Table 1). Three states (Kenya, Tanzania, and Zimbabwe) differentiated between the severity of sentences for poaching rhinos rather than elephants before recent law changes, and another state (Malaysia) since its law change. Before the law changes, the real value of penalties, whether fines or prison sentences, was fairly uniform in the seven states where data are available, with the exception of the long prison sentences in Tanzania (Table 1). But the law changes have led to much wider variation in the real value of penalties for poaching rhinos and elephants. Of possible concern are the generally lower penalties in the two Asian countries, which have responsibility for the two most endangered species with the most valuable trophies, Javan and Sumatran rhinos.

In addition to changes in fines and prison sentences, three countries—Zaire, Zimbabwe, and Kenya—have attempted to deter poaching by using a shoot-to-kill policy (Table 1). In these countries, nationals of other countries have been the chief illegal exploiters of rhinos and elephants: Sudanese in Zaire, Zambians in Zimbabwe, and Somalis in Kenya. Crossing frontiers with automatic weapons represents a threat to national security that, together with poaching, is deemed to merit such a punishment (Tatham 1988).

The question, then, is whether the policy of stiffer sentences will work. As discussed earlier, studies suggest that long prison sentences do not work when discount rates are positive, as they are in Africa. Very high fines are unlikely to be paid. A disadvantage of a very high penalty is that although it may lower the overall level of crime, the level of serious crime may increase (Stigler 1970). Local poachers may move to serious crime if punishment is unselective. Therefore, a shoot-to-kill policy should not be applied to all poachers entering a Protected Area, for then there is no incentive to kill just a warthog rather than an elephant or rhino, and not to kill approaching scouts. But are the organized gangs deterred by the death penalty? No data are available from Kenya. In Zimbabwe, small gangs without carriers hunt for rhino horn, so the policy stands the best chance of success here because a high proportion of hunters are killed. Around 164 Zambian poachers were shot between 1984 and 1992, however, and a minimum of 1105 rhinos were killed (Milliken et al. 1993).

The implication of the failure to control poaching with the death penalty is that the stiffest possible penalty is not in itself an effective deterrent to poaching in Africa. We suggest that wildlife authorities should not simply press for more severe penalties (Table 1), but instead put their primary emphasis on improving their detection rates to levels that deter poachers, with secondary emphasis on achieving more severe penalties for

those involved in serious crimes. Efficient detection is clearly the responsibility of the wildlife authority. Severe penalties in law may be unhelpful if detection rates remain low and/or if the judiciary does not pass the mandatory sentence, as occurred in Luangwa Valley (Leader-Williams et al. 1990). A shoot-to-kill policy is advantageous to a wildlife authority in that, once political approval has been granted, its administration is solely within the wildlife authority's control.

Community schemes have been shown to be effective in deterring local poaching both in Zambia (Lewis et al. 1990) and elsewhere. For example, local people acting as auxiliary game guards have reduced rhino poaching in Namibia (Loutit & Owen-Smith 1989). However, poaching by organized gangs may not be as successfully tackled through community schemes as poaching by locals, especially when gangs come from outside project areas or are non-nationals. An aware local population may well provide information on poaching incursions, but the killing of rhinos by Zambians (Milliken et al. 1993) within areas included in the well-known CAMPFIRE project in Zimbabwe (Martin 1986) attests to the inadvisability of relying on community schemes to stem the tide of organized poaching.

Trade bans are a possible solution to protecting populations of endangered animals, but they have certainly not worked for rhinos (Western 1989; Leader-Williams 1992), and it is too soon to evaluate them for elephants (Dublin & Jachmann 1992). If bans continue to be ineffective, our analysis gives a gloomy prognosis for the protection of large populations of rhinos and elephants from organized poaching gangs. The problem is especially acute in countries (or in their neighboring countries) with imperfect law enforcement and declining economies and where dealers enjoy an almost zero rate of detection (Cumming 1986). Given that a high probability of detection is a better deterrent than a severe penalty, wildlife authorities need to direct manpower into law enforcement patrols and, if resources are short, effort should be concentrated on the protection of small areas rather than spread thinly (Leader-Williams & Albon 1988) or, where possible, devoted to considerably more effective intelligence work outside the protected areas (Bell 1986; Leader-Williams et al. 1990).

Acknowledgments

N. Leader-Williams's fieldwork was undertaken with permission from the National Parks and Wildlife Service, Zambia, with the support of G. B. Kaweche and G. Mubanga. Financial support was provided largely by the People's Trust for Endangered Species and the Norwegian Agency for International Development, with additional grants from the Fauna and Flora Preservation Society and the New York Zoological Society. Sponsorship

of project logistics and costs in Zambia was organized by Rover Zambia, Dunlop Zambia, and Zambia Oxygen through SRT. We thank the following individuals for responding to our questionnaire on changes in wildlife legislation: R. A. Brett (Kenya), E. Joubert (Namibia), P. M. Brooks (South Africa), L. Melamari and M. M. Lymio (Tanzania), K. Hillman-Smith (Zaire), R. H. V. Bell (Zambia), R. F. du Toit (Zimbabwe), W. Ramono and C. Santiapillai (Indonesia), and A. R. B. Samsudin (Peninsula Malaysia). We thank Professor J. R. Beddington for his support and advice. The manuscript was prepared while N. Leader-Williams held a Leverhulme Research Fellowship and a grant from the Condor Trust for Conservation.

Literature Cited

- Avio, K. L., and C. S. Clark. 1978. The supply of property offences in Ontario: Evidence on the deterrent effect of punishment. *Canadian Journal of Economics* 10:1-19.
- Becker, G. S. 1968. Crime and punishment: An economic approach. *Journal of Political Economy* 76:168-217.
- Bell, R. H. V. 1986. Monitoring of illegal activity and law enforcement in African conservation areas. Pages 315-317 in R. H. V. Bell, and E. McShane-Caluzi, editors. *Conservation and wildlife management in Africa*. Peace Corps, Washington, D.C.
- Chapter 316 of the Laws of Zambia. Government Printer, Lusaka, Zambia.
- Cook, P. J. 1977. Punishment and crime. *Law and Contemporary Problems* 5:164-204.
- Cumming, D. H. M. 1986. Chairman's report. *Pachyderm* 7: 1-3.
- Dublin, H., and H. Jachmann. 1992. The impact of the ivory ban on illegal hunting of elephants in six range states in Africa. *World Wildlife Fund International*, Gland, Switzerland.
- Ehrlich, I. 1973. Participation in illegitimate activities: A theoretical and empirical investigation. *Journal of Political Economy* 81:521-565.
- Ivory Trade Review Group (1989). *The ivory trade and the Future of the African Elephant*. Queen Elizabeth House, Oxford, United Kingdom.
- IUCN 1986. *African wildlife laws*. Environmental Law Center, International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland.
- Leader-Williams, N. 1992. The world trade in rhino horn: A review. *TRAFFIC International*, Cambridge, England.
- Leader-Williams, N., and S. D. Albon. 1988. Allocation of resources for conservation. *Nature* 336:533-535.
- Leader-Williams, N., S. D. Albon, and P. S. M. Berry. 1990. Illegal exploitation of black rhinoceros and elephant populations: Patterns of decline, law enforcement and patrol effort in Luangwa Valley, Zambia. *Journal of Applied Ecology* 27:1055-1087.

- Lewis, D. M., G. B. Kaweche, and A. Mwenya. 1990. Wildlife conservation outside protected areas: Lessons from an experiment in Zambia. *Conservation Biology* 4:171–180.
- Loutit, R., and G. Owen-Smith. 1989. The auxilliary game guard system in north-western Namibia and its role in black rhinoceros conservation. *Koedoe* 32:85–86.
- Marks, S. A. 1976. Large mammals and a brave people: Subsistence hunters in Zambia. University of Washington Press, Seattle, Washington.
- Marks, S. A. 1984. The imperial lion: Human dimensions of wildlife management in central Africa. Westview Press, Boulder, Colorado.
- Martin, R. B. 1986. Communal area management plan for indigenous resources. Pages 279–295 in R. H. V. Bell and E. McShane-Caluzi, editors. Conservation and wildlife management in Africa. Peace Corps, Washington, D.C.
- Milliken, T., K. Nowell, and J. B. Thomsen. 1993. Redefining rhino conservation for the 21st century: A review of Zimbabwe's strategy to save the black rhino. TRAFFIC International, Cambridge, England. In press.
- Milner-Gulland, E. J., and N. Leader-Williams. 1992. A model of incentives for the illegal exploitation of black rhinos and elephants. *Journal of Applied Ecology* 29:388–401.
- Parker, I. S. C., and A. D. Graham. 1989. Men, elephants and competition. Symposium of Zoological Society of London 61:241–252.
- Stigler, G. J. 1970. The optimum enforcement of laws. *Journal of Political Economy* 78:526–536.
- Tatham, G. 1988. The rhino conservation strategy in the Zambezi Valley, Zimbabwe, code named Operation Stronghold. *Zimbabwe Science News* 22:21–23.
- Tatham, G. H., and R. D. Taylor. 1989. The conservation and protection of the black rhinoceros *Diceros bicornis* in Zimbabwe. *Koedoe* 32:31–42.
- Thurow, L. C. 1980. Equity versus efficiency in law enforcement. Pages 85–92 in R. L. Andreano and J. J. Siegfried, editors. *The economics of crime*. Halstead, New York, New York.
- Western, D. 1989. The undetected trade in rhino horn. *Pachyderm* 11:26–28.

