

How Much Rhino Horn has come onto International Markets since 1970?

Esmond Bradley Martin and T.C.I. Ryan

To deal with the international trade in rhinoceros horn it is essential that all major markets are known. If the number of rhinos dying during a certain period is estimated and the equivalent horn weight compared with total identified sales over the same time, then some indication of whether a so-far unidentified market exists should be evident. Undoubtedly there is a large difference between the weight of horn from dead rhinos and that vended, and this apparent discrepancy has led Western to postulate that some large market remains undiscovered. We argue against this and show that supply and demand agree within reasonable limits of error.

Asian rhinos supply a small but very valuable part of the total weight of rhino horn. The amount of Javan rhino horn put onto the market since 1970 has been negligible because so few have died. In 1969 the Schenkels, who were working in the Ujong Kulon Reserve in Western Java where probably the only viable Javan rhino population exists, estimated that there were 25 animals.¹ This population expanded to just under 60 by 1979 but declined to 54 in 1984,² largely due to disease which killed at least five animals in 1981 and 1982, and it has remained at about 55 since then. From 1967 to 1986 there was very little poaching of Javan rhinos,³ but some died from natural causes. Perhaps no more than three horns on average (Javan rhinos have only one horn) could have been supplied to middlemen each year, so probably less than two kg of Javan horn have been sold annually.

It is not known how many Sumatran rhinos existed in 1970; conservationists were grossly underestimating their numbers long before then. In 1958 Bernhard Grzimek wrote that the world population of this species was no more than ten.⁴ In 1968 Werner T. Schaurte, in an IUCN publication, estimated between 150 and 170;⁵ and a year later Rudolf Schenkel, then Chairman of the IUCN Asian Rhino Specialist Group, and E.M. Lang estimated that there were between 50 and 100 Sumatran rhinos left.⁶ The most recent range, supplied by Nico van Strien, is the most realistic: between 539 and 991.⁷ This conforms to what wildlife traders believe, and also it makes sense when we consider what is known about the supply of Sumatran rhino horn, hide, nails and other products found on markets since 1970. This species has been under dire threat from poachers and has also lost much of its natural habitat; during the past ten years we have found a reasonably large quantity of Sumatran horn for sale in the traditional medicine shops of eastern Asia. It seems likely that there must have been a minimum of 2,000 Sumatran rhinos in 1970. Bearing in mind the annual recruitment rate, this population could have sustained 3,000 deaths during the 18-year-period to date. Since the mature Sumatran rhino carries horns totalling about 269 gm in weight,⁸ the carcasses could have-yielded at most an average 45 kg of horn per year. But of the 3,000 a number Would have died from natural causes in the depths of the tropical rain forest which is their home; the horn on these animals would be lost. Thus a figure of 25 kg annually would be a more probable figure for the amount of horn coming to the trade.

For Indian rhinos the statistics are fairly accurate because censuses have been carried out over the past quarter-century in both India and Nepal by wildlife departments' personnel⁹ and independent scientists such as G. Caughley,¹⁰ A. Laurie,¹¹ J. Spillett¹² and E. Dinerstein.¹³ Also there is information available on Indian rhino horn entering the market as some has been sold officially, unlike the case of Sumatran rhino horn.

From 1969/1970 to 1978/1979 the Assam Forest Department sold 210.39 kg of Indian rhino horn.¹⁴ Some 39.50 kg offered for tender in 1979/1980 were not sold due to criticism against marketing a product from an endangered species and since then no rhino horn has been sold officially by any Indian authority. All horn collected from dead rhinos is being stockpiled. In addition to that sold officially poached horn was, and still is, available to traders. Twenty-seven Indian rhinos were illicitly killed between 1970 and 1978 in Kaziranga National Park, Assam,¹⁵ where 75% of Indian rhinos live. From 1979, figures for the whole of Assam, which contains 95% of the total Indian rhino population (1,295 in 1986), show that a minimum of 400 animals were poached in the nine years up to December, 1987.¹⁶

Given an average weight of 722gm per horn¹⁷, the poached animals yielded some 310 kg of horn which together with official sales make a minimum total of some 520kg put onto the market from Assam between 1970 and 1987. Furthermore, during this period some rhinos were poached in the state of West Bengal¹⁸ and Nepal's Royal Chitwan National Park; these supplied perhaps another 40 kg to traders. Horn recovered from rhinos found dead of natural causes in Chitwan after 1975 has not been sold nor put onto the international market.¹⁹ It would, therefore, seem that the total amount of horn from the greater one-horned rhinoceros over the past 18 years is at least 560kg, an average of 31 kg per year.

Table
Estimates of Asian Rhino Horn coming onto the Market

Species	Average kg per year	@	Av. horn wt. per animal (gin)	=	Approximate no. of rhinos
Javan	2		676		3
Sumatran	25		269		93
Indian	31		722		43
	—				
Total	58kg				

(NB: When compared with the more than 50 times as much African rhino horn on the market this total weight is very small but its value is astounding. At some US\$ 10,000 a kg the wholesale value per annum is US\$ 580,000 whereas 3,000 kg of African horn would fetch US\$ 2,000,000.)

While African rhinos have provided the market with over 50 times as much weight of rhino horn as have the Asian animals quantifying the amount exported to Asia, using sources within Africa, has proved to be impossible because of the lack of reliable data. Most African countries have no statistics at all and of those that have published annual customs reports on rhino horn exports, such as Kenya and Tanzania, the amounts shown are roughly only half of what actually went out.²⁰ Of the 19 African countries still possessing wild rhino populations none now has legal trade in rhino products and practically all horns that leave the continent are smuggled: it is also now illegal for most Asian consumer countries to import rhino products. Even in the early and mid- 1970s, when trade in rhino horn was mostly legitimate, some major user countries, such as China and Hong Kong, kept no records of imports while the official statistics from Taiwan, Japan and South Korea were inaccurate as import levies encouraged both smuggling and the falsification of in-voices.²¹ In North Yemen, which was the single largest rhino horn importing country from 1972 until the early 1980s, the official statistics for the 1970s are erratic and for the 1980s non-existent.

Let us look first at the estimates for black and white rhino populations. David Western and EBM calculated that there were 65,000 black rhinos in 1970, using data from John Goddard for East Africa, counts for southern Africa and by applying studies of rhino population densities to central and west Africa. This figure has been generally accepted as a reasonable approximation. From the combined efforts of over 30 scientists, including Kes Hillman, David Cumming, Anthony Hall-Martin and Martin Brooks, all members of the IUCN African Elephant and Rhino Specialist Group, David Western and Lucy Vigne obtained estimates for 1980 of 14,785²³ and 8,800 for 1984²⁴. In 1987, the Nyeri meeting of the IUCN African Elephant and Rhino Specialist Group determined a figure of 3,832.²⁵ However, as anyone who has attempted to conduct a rhino count will readily agree, it is extremely difficult to locate these animals in the thick bush where they live and most estimates, including those above, are likely to be below the true figure.²⁶

For white rhinos it is assumed that there were about 3,900 (2,000 northern and 1,900 southern) in 1970, 3,840 in 1980,²⁷ 3,948 in 1984²⁸ and 4,600 (50 northern and 4,550 southern) in 1987.²⁹

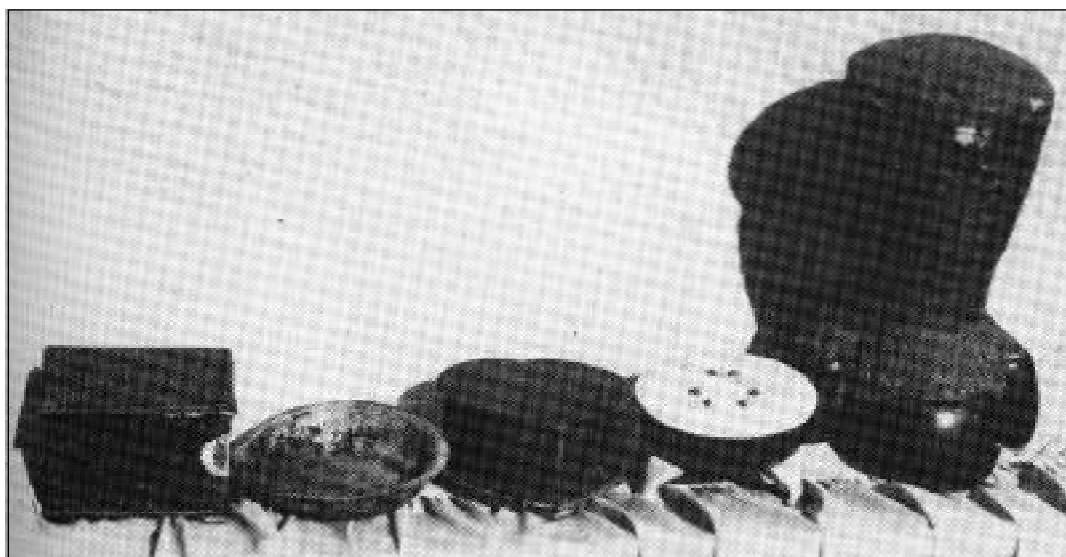
In determining the number of white rhino deaths and hence the amount of horn, it would be illogical to apply a common recruitment rate to both the northern and southern populations. The northern population has been severely reduced by poaching from some 2,000 animals in 1970 to less than 50 today and will have only a small recruitment rate. Conversely, with the exception of those animals in Mozambique³¹ where some have been poached, the southern population is youthful and will have a low natural death rate and high recruitment rate.

Using a 3% mortality rate for the southern group³² and a small recruitment rate for the northern then perhaps 4,350 white rhinos have died since 1970. If 80% of these were adults carrying an average of four kg of horn apiece³³ and assuming half of the horn was not found, then some 7,000 kg of white rhino horn came onto the market from 1970 to 1987.

It is worthy of note that although the figures as to the status of the white rhino appear very encouraging we should remember that in 1970 there were about 2,000 spread among Zaire, the Central African Republic, Sudan and Uganda and that practically all these are now dead. It is the strides in conservation management made by South Africa that have made the numbers look comparatively healthy: the population in South Africa has more than doubled in the past 18 years.

Black rhinos have been the source of the greatest weight of horn reaching the market. Our arguments on this source of horn are therefore somewhat more detailed.

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All the objects here were made from various parts of a greater one-horned rhino for General Kiran Shumsher Rana whose father was a prime minister in Nepal.

Once trade becomes illegal, dealers are naturally reluctant to disclose the amount of horn they are bringing into their countries. Nevertheless, it is possible to develop a rapport with certain traders who will then discuss their business practices and, with the advantage of having started research on the international trade in rhino products before many restrictions were imposed, Esmond Bradley Martin has been able to discover much about supply and demand. In some instances, on condition of anonymity, major traders have divulged certain facts which over the years we have been able to cross-check and confirm. These and other information confirms that the estimate EBM published for the average annual amount of rhino horn which left Africa between 1970 and 1979, a minimum of eight tonnes, is still valid. From 1980 to 1987, EBM has estimated that exports of horn fell to three tonnes a year.²² The essence of our argument is that these estimates are consistent with the death rates of rhinos over the years: that the error between the possible supply of horn and the known use or demand is negligible in terms of the uncertainty in the parameters used.

During the mid-1960s the first reasonably accurate census of rhinos in Tsavo East Park, based on stratified random samples, was made by John Goddard.³⁴ stated that the population was stable, estimated the number of rhinos in Tsavo East to be $4,200 \pm 25\%$, and calculated that the annual recruitment rate was 10.9%. Goddard's finding of a 10.9% recruitment rate on a stable population implies a death rate also of 10.9%.³⁵ The observed population was not under particular duress, so we may conclude that 10.9% is the natural death rate.

Western argues that when a population comes under heavy poaching pressure the recruitment rate is between 7% and 10.9% and Rob Brett considers that a 7% recruitment rate is more likely than 10.9%.³⁷ The lower figure would seem more plausible for a variety of reasons, ranging from the wider dispersion of individuals to the increased killing of fertile females.

It is possible to calculate the death rate which would reduce the number of animals estimated for 1970 to the estimate for 1980, and similarly for the periods 1980 to 1984 and 1984 to 1987, taking into account the annual increment for recruitment. If the initial population is P_s , the final population P_F , the death rate $d\%$, the recruitment rate $b\%$ and the period of years is n then $P_F = P_s \cdot R^{nb} \cdot R^{nd}$ where $R^d = 1 + d/100$ and $R^b = 1 + b/100$.

The figures given in the Appendix were obtained by adding the births to each year-start number and then subtracting the deaths. Then summing the deaths each year gives the approximate number of dead rhinos since 1970.³⁸ (If deaths are subtracted from the year-start figure before births are added then the total number of rhinos dying over the period would reduce by more than 15%. We will take the higher figure in conformity with our policy of maximizing supply and minimizing demand estimates.)

The calculations yield a total of some 93,800 dead rhinos at the 7.5% recruitment rate. Of these, 20% would be juveniles carrying little or no horn, and the remaining 75,100 would have horns weighing on average 2.88 kg.³⁹ The maximum amount of black rhino horn which could have been produced would thus be some 216,100 kg.

A lot of this horn never would have reached the international market. It is made of keratin fibres which rapidly deteriorate under wet conditions and also is destroyed quickly by insects. In areas of high rainfall such as Zambia, the Central African Republic, southern Tanzania and parts of Kenya, it is unlikely that rhino horn on a carcass would last more than a few weeks during the rainy season. Thus a considerable quantity of horn from rhinos dying of natural causes would never be recovered. Partially damaged horn is difficult to sell and only in South Korea is there a demand for that which has been riddled by insects. During the 1970s the main market for African rhino horn was North Yemen; it was the easiest and closest market to supply, but buyers there would accept only good quality horn; they could not use damaged horn to carve dagger handles. Consequently, even when poor quality horn was found, it would not usually be collected. Moreover, few people lived in the places where large numbers of rhinos existed in the 1970s, such as the vast wildlife sanctuaries of Luangwa Valley, Zambezi Valley and the Selous, and so chance discovery of horn was uncommon.

A recovery rate is the percentage of a total product that is found by chance and/or search. Regrettably, no investigation has been made

of such rates for rhino horn in Africa. However, Ian Parker in his major report, "The Ivory Trade", reviewed the recovery rates for elephant ivory over the period 1950 to 1978. The tusks picked up by the authorities in various parks included those from wounded animals which escaped illicit hunters as well as those from animals dying naturally. According to Parker, official recovery rates for ivory varied from 84% of the mortality in a small, well-patrolled park such as Manyara to 8% in Tsavo which is vast and understaffed. Given the predisposition of rhinos to live in thick vegetation which reduces the visibility of both live and dead animals, and the fact that their horns perish quicker than ivory, it is doubtful that the recovery rate for rhino horn could ever be as high as that for ivory. According to Ian Parker, within the large parks and game reserves where the majority of Africa's rhinos lived in the 1970s the recovery rate would have been lower than the 8% figure estimated for ivory in Tsavo.⁴¹

The records kept by the authorities in Tsavo East Park show that the recovery of rhino horn by the park's staff and other officials has always been extremely low, even when Tsavo was well-managed in the 1960s. From 1962 until 1967 between 42 and 75 rhino horns were officially collected each year, the annual average being 62, representing 31 dead rhinos.⁴² On the basis of Goddard's findings, each year of the mid-1960s an average 458 rhinos (10.9% of 4,200) should have died, but the authorities picked up horns from only 31 rhinos or 7% of the estimated number of dead animals. We do not know how many horns were collected by poachers nor, more importantly, do we know what percentage of the horn was never found or was in such poor condition it was simply left in the bush.

In 1976, 56 horns were officially collected from the many hundreds of rhinos remaining in Tsavo East but then poaching escalated and the standard of management declined and in 1977 only 16 horns were found. From 1978 to 1987 not a single one was handed into Park headquarters.⁴³ The story was practically the same for Kenya's other parks: Tsavo West's park staff collected a total of only 14 horns between 1978 and 1985,⁴⁴ in



During the 1970s Japan was one of the world's largest importers of rhino horn; shown on a book here are small pieces of sliced rhino horn which were later sold as medicine to lower fever, cure measles, stop nosebleeds and alleviate blood poisoning.



An official of Nepal's Royal Chit wan National Park displays some rhino horns, hooves and a piece of hide collected from dead rhinos, which were later sent to the King's Palace in Kathmandu.

Aberdare Park from 1977 until 1986 only 22 horns were officially recovered,⁴⁵ although that park's rhino population was estimated to be 600 in 1978.⁴⁶ What happened in Kenya's parks from 1976 onwards was that illicit hunters took more horns and some officials misappropriated those that were found.

The low official recovery rate of 7% for rhino horn in Tsavo East in the mid-1960s is not typical of all parks. In Meru National Park from 1969 to 1974 there were an estimated 200 black rhinos⁴⁷, and heavy poaching had not yet begun. Taking the usual 10.9% mortality rate, 22 rhinos would be expected to die per year in Meru. Over the six-year period 55 horns were officially found⁴⁸, representing an average annual recovery rate of 21%. For Nairobi National Park, a small reserve which has had little rhino poaching since the major translocation of rhinos into it between 1966 and 1968,⁴⁹ the official recovery rate is probably the highest of all East Africa's parks. Using Goddard's mortality rate on a population of 30 to 35 during the 1970s and the 14 horns known to have been handed to the authorities between 1979 and 1981⁵⁰, the recovery rate is in excess of 75%.

We will assume that Tsavo East's and Meru's recovery rates are closer to reality for most areas containing large rhino populations than that for Nairobi Park because in the 1960s and 1970s most black rhinos in Africa lived in reserves similar to Tsavo East and Meru. We therefore estimate 14% at most (i.e. the un-weighted average of the recovery rates for Tsavo East and Meru)

as the recovery rate of horn from animals dying a natural death. We also assume that poachers would generally be successful in collecting the horn from their victims.

Sport hunting for rhinos accounts for a small but quantifiable amount of horn. Until the mid-1970s, and until 1979 in Zambia,⁵¹ most countries with rhino populations allowed licensed hunting. Mozambique, Tanzania, Zambia, Kenya, the Central African Republic and Sudan attracted many foreigners from Europe, North and South America by offering them the opportunity to shoot one of the "Big Five". It was expensive to hunt a rhino for sport because licences had to be purchased from the government and the safari firms which organized the hunts charged high fees. The horns from a minimum of 600 rhinos shot on licence between 1970 and 1979 were usually exported by the visiting sportsmen who would normally retain them as trophies and so the horn did not enter the market.

Other African rhino horn unavailable to the market would be that from animals exported live to safari parks and zoos throughout the world. Over 1,500 rhinos have left Africa since 1970 to go to new homes, most of these animals being white rhinos from southern Africa.

Since the mid-1970s and early 1980s, when most of the official bans on export of rhino horn were established in African countries, various government departments have stockpiled horn confiscated from traders and poachers and that recovered from the bush. Several of these stockpiles are now substantial amounts. The largest is held by the Natal Parks Board which in April, 1987, had 1,692 kg. Zimbabwe officially has over 750 kg, Kenya 247 kg (as of October, 1986), 53 Namibia 173 kg (as of May, 1987), and the South African National Parks had 100 kg in their strongrooms in 1987.⁵⁵ The Zambian government has a small quantity (55 kg in January, 1985)⁵⁶ and so does Tanzania (31 kg in September, 1987).⁵⁷ A few other African countries have some as well. Therefore, by the end of 1987 there was a minimum of 3,100 kg (in southern Africa mostly from white rhino) which had not been exported. Aside from that held officially, some traders and collectors in Africa retain rhino horn which must amount to at least half a tonne in total.

Some rhino horn kept in government storehouses has deteriorated. In 1987, when EBM last visited the Ivory Room in Mombasa where the Kenya Wildlife Conservation and Management Department traditionally keeps game trophies, the majority of the horns he saw were in appalling condition, and some even fell apart in his hands. Insects and high humidity are responsible for the damage and these have taken toll also of government-owned stocks held in Dar es Salaam.

At the first meeting of the African Rhino Specialist Group, in Kenya during 1980, a programme to try to end trade in rhino horn was initiated and one of the recommendations made was that governments should destroy the stocks of rhino horn they held **to** prevent them from ever going onto markets. As far as we know, only Pilanesburg Game Reserve in Bophuthatswana did this: officials burned 35 kg in early 1981.⁵⁸

One more reduction in the weight of horn available to the market should be made due to the perishable nature of the commodity and consideration of the fact that it is smuggled between countries. There is no way of telling what this amount would be, but perhaps a couple of percent of the horn destined for Asia

from Africa is lost or damaged *en route*.

Lastly, some would be found and given neither to the authorities nor the trade. The rhino horns displayed for tourists in ledges and hotels are examples. Additionally a number of African peoples have their own uses for rhino horn. For example Zulu men burn rhino horn when they find it and daub the ash on their eyebrows to attract beautiful women,⁵⁹ Zimbabweans in the 1970s purchased rhino horn from traditional doctors in Harare's Pedzanhama market for use as a talisman to give them strength and power and to protect their homes from evil spirits⁶⁰ and Sudanese in Khartoum made boxes out of rhino horn until quite recently.⁶¹

As was earlier remarked, those who have studied the black rhino populations have come up with accepted numbers for four years: 1970, 1980, 1984 and 1987. These numbers were computed in various ways and do not relate to any particular time of the year. Since we need base numbers to make our calculations of rhino disappearance and not wishing to imply a greater accuracy than, perhaps, the data warrant, we have chosen to round the numbers to the nearest hundred and assume that they relate to the beginning of the year of observation i.e. 65,000 (1970), 14,800(1980), 8,800 (1984) and 3,800 (1987). These are the numbers used in the computations in the Appendix where a variety of recruitment rates (7.5%, 5%, 4%, 3%) have been applied to calculate the implicit death rates necessary to achieve these population changes.

The death rates vary in the three time periods and show the expected very large increase in 1984 -1986 (inclusive) during which time poaching was thought to have increased in response to the very large rise in the price of rhino horn.

The annual sales to identified markets have been presented. These, of necessity, are annual averages over spans of years: 8,000 kg per annum between 1970 and 1979 and 3,000 kg per annum from 1980 to 1986, all data inclusive. Since the average black rhino produces 2.88 kg of horn, these figures account for 2,780 rhinos annually over the decade of the 1970s, giving 27,800 rhinos; and 1,040 rhinos annually up to 1987, giving 7,280 rhinos. These compare with the dead rhinos of the 1970s — using a 7.5% recruitment rate — of 77,572 and 16,230 in the recorded years of the 1980s. That there is no major discrepancy between these figures is shown in the following analysis which considers a variety of corrections which must be made to both the supply and demand figures.

There has always been a demand for rhino horn within Africa, ranging from Sudanese box-making to talismans; this is estimated at some 15 rhinos per year throughout the period. Until sport hunting was comprehensively banned in 1979, a minimum of 63 rhinos were killed annually on licence. On average, about 29 black rhinos per year have been exported live to zoos and safari parks. Legal stockpiles have grown to about 3,600kg since 1978 and this figure would have been say 20% greater if the horn was stored efficiently. Stockpiles of 4,200 kg would represent 170 rhinos annually. These four items would increase the demand figures by approximately 1,240 in the 1970s and 1,500 in the 1980s to totals of 29,040 and 8,780 respectively.

Considering the supply figures, if we accept Western's 20% of deaths as juveniles which do not contribute horn, the numbers to be accounted for in the market are significantly reduced to 62,057 in the 1970s and 12,984 in the 1980s and of these animals approximately half died natural deaths. Taking the Goddard death

Appendix

Numbers of dead black rhinos from 1970 . 1987 using recruitment rates of 5%, 4% and 3%, and base black rhino populations for 1970(65,000), 1980(14,800), 1984(8,800) and 1987(3,800)

Year	7.5%	5.0%	4.0%	3.0%
1970	13,816	12,191	11,541	10,891
1971	11,915	10,514	9,953	9,393
1972	10,276	9,068	8,584	8,101
1973	8,863	7,820	7,403	6,986
1974	7,644	6,745	6,385	6,025
1975	6,592	5,817	5,507	5,197
1976	5,686	5,017	4,749	4,482
1977	4,904	4,327	4,096	3,865
1978	4,229	3,732	3,533	3,334
1979	3,647	3,218	3,047	2,875
(70s totals	77,572	68,449	64,798	61,149)
1980	2,914	2,544	2,396	2,248
1981	2,559	2,234	2,104	1,974
1982	2,247	1,962	1,847	1,733
1983	1,973	1,722	1,622	1,522
(80s subtotals	9,693	8,462	7,969	7,477)
1984	2,809	2,589	2,501	2,413
1985	2,123	1,957	1,890	1,824
1986	1,605	1,479	1,429	1,378
(80s subtotals	6,537	6,025	5,820	5,615)
Total dead rhinos	93,800	82,934	78,587	74,240

(All numbers rounded to the nearest whole integer)

Deaths per 1,000 rhinos per year given various recruitment rates

Period	Recruitment rates			
	7.5%	5%	4%	3%
1970-1979	198	179	171	163
1980-1983	183	164	156	147
1984-1987	297	280	273	266

(All numbers rounded to the nearest whole integer)

rate of 10.9% of the population, natural deaths would account for 42,764 in the 1970s and 8,947 in the 1980s or, ignoring juveniles, 34,211 and 7,157 respectively. Earlier in this paper we have argued that the empirical evidence indicates a low recovery rate of 14% of horn from rhinos which die naturally. Of the 42,764 natural deaths this would mean some 5,987 found and for the 1980s figure of 7,157 natural deaths 1,002.

The supply of horn would then be obtained from total adult deaths less natural deaths plus the 14% of natural deaths recovered. This represents a total of 62,057-34,211+5,987 = 33,833 for the 1970s and 12,984 -7,157+1,002 = 6,829 in the 1980s.

Comparison of the 33,833 supply for the 1970s with the known demand of 29,040 implies that poachers were successful in getting the horn from 85% (29,040/33,833) of the animals killed or that some 1,380kg of horn are unaccounted for annually. For the 1980s, the demand appears to exceed the supply.

In view of these calculations and their conclusions, it seems that little rhino horn is unaccounted for. Finer analysis of the demand side might clarify whether there were occasional bumps which would explain the disappearance of the surpluses in the 1970s and mid-1980s if poacher recovery truly was about 100%. Nevertheless a fairly small decrease in the population estimate for 1970 would remove completely the unaccounted surplus.

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26. Johns Goddard, "The Validity of Censusing Black Rhinoceros Populations from the Air", *East African Wildlife Journal*, No 5 (August1967), pp 18-23.
27. Western and Vigne, p216.
28. Western and Vigne, p216.
29. AERSG Nyeri Meeting estimate.
30. Personal Communication with Kes Hillman, Nairobi, 8 June 1988.
31. During this century white rhinos became extinct in Mozambique, were re-intro-duced and died out again due to poaching.
32. Rupert Norman Owen-Smith, "The Behavioural Ecology of the White Rhinoceros", *Dissertation Abstracts International* Vol XXXIV, No 10, 1974 (summary of PhD dissertation presented to the University of Wisconsin, 1973).
33. Martin, "Rhino Horn Weights", p27.
34. John Goddard, "Aerial Census of Black Rhinoceros Using Stratified Random Sampling", *East African Wildlife Journal*, No 7(1969), p 110.
35. John Goddard, "Age Criteria and Vital Statistics of a Black Rhinoceros Population", *East African Wildlife Journal*, No 8(1970), pp 105 and 119.
36. David Western, "The Undetected Trade in Rhino Horn", *Pachyderm*, No 11 (1989), p27.
37. Rob Brett, Personal Communication, Nairobi, 1989.
38. David Western ascertained an annual recruitment rate of 7% for the Amboseli rhino population which was declining due to poaching (David Western and Daniel M. Sindiyo, "The Status of the Amboseli Rhino Population", *East African Wildlife Journal*, Vol X (1972), p 50). On the other hand, John Goddard estimated that the annual recruitment rates for stable black rhino populations in East Africa varied from 7.2% to 10.9% (John Goddard, "Home Range Behaviour and Recruitment Rates of the Black Rhinoceros Populations", *East African Wildlife Journal* No 5 [1967], p 147; and John Goddard, "Age Criteria", p 119).
39. Martin, "Rhino Horn Weights", p27.
40. I.S.C. Parker, "The Ivory Trade", a consultancy undertaken for Dr Iain Douglas-Hamilton on behalf of the United States Fish & Wildlife Service of the Department of the Interior, and IUCN (June 1979).
41. Ian Parker, Personal Communication, Nairobi, 4 June 1988; and Parker "The Ivory Trade", Vol II, pp 191-192 and Vol IV, Tables 220 and 222.
42. Statistics from Rhino Horn Records: Tsavo East National Park (notebook).
43. Statistics from Rhino Horn Records: Tsavo East National Park (notebook).
44. Statistics supplied by officers of Tsavo West National Park to the Wildlife Conservation and Management Department.
45. Statistics from Trophy Register: Aberdare National Park (notebook).
46. Kes Hillman and Esmond Bradley Martin, "Count-down for rhino in Kenya", *Africana*, Vol VI, No 12(3rd quarter 1979), p6.
47. Interview with Peter Jenkins, former Warden of Meru National Park, 20 October 1988.
48. Statistics (unpublished) from Meru National Park.
49. PM. Hamilton and J.M. King, "The Fate of Black Rhinoceroses Released in Nairobi National Park", *East African Wildlife Journal*, No 7(1969), p 75.
50. Statistics from Nairobi National Park Register (notebook).
51. From 1973 to 1979 in Zambia a total of 178 rhinos were legally shot by clients of safari companies; the 178 rhinos produced 328.5 kg of horn (Letter from Director of National Parks and Wildlife Service to the Chief Wildlife Warden, Chilanga, 10 January 1980).
52. Letter from Martin Brooks, Chief Professional Officer (Research), Natal Parks Board, to Esmond Bradley Martin, 27 April 1987.
53. Information supplied by the Kenya Wildlife Conservation and Management Department, 1986.
54. Letter from the Director, Nature Conservation and Recreation Resorts, Department of Agriculture and Nature Conservation, South West Africa, to Eamond Bradley Martin, 26 June 1987.
55. Letter from Martin Brooks, to Esmond Bradley Martin, 27 April 1987.
56. Information from the Zambian National Parks ad Wildlife Service, July 1985.
57. Letter from S.D. Kihale, Ministry of Natural Resources and Tourism, Ivory Room, Wildlife Division, Dares Salaam, to Esmond Bradley Martin, 22 September 1987.
58. J.L. Anderson, "Controversies in Rhino Conservation", *Tshornarelo News*, No 7 (October 1982), pp 12-14; and interview with J.L. Anderson, Director of the Pilanesburg Game Reserve, Pilanesburg, 28 October 1981.
59. Interview with T. Naidoo of the Zulu Muti Shop, Johannesburg, 26 November 1981.
60. Interviews with Milton Refa and Godfrey Bingepinge, sellers of traditional medicinal products, Pedzanhamo market, Harare, 18 July 1983.
61. Personal Communication with Ian Parker, Nairobi, 4 June 1988.



These black rhino skulls were photographed in South Luangwa National Park, Zambia, in 1983. During the 1970s and 1980s thousands of rhinos succumbed to poachers in the Luangwa Valley, and today probably less than 200 rhinos survive in Zambia.