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**WHITE RHINO IN HLUHLUWE-UMFOLOZI PARK,
SOUTH AFRICA
HAVE 800 BEEN "LOST" ?**



February 1995

Key issue reports provide information and balanced perspectives on critical rhino conservation issues to aid policy formation and decision-making.

The IUCN's Species Survival Commission's African Rhino Specialist Group (AIRSG) is tasked with providing information and advice on the status and management of African rhinos to African Range States, and to all Government and Non-Governmental conservation agencies. It assists in the development of conservation plans and management strategies, with the aim of ensuring the survival of African rhino, and their recovery to viable levels.

The Chairman and members are drawn from 15 countries, and comprise both

representatives of the major African rhino Range States, and rhino specialists in the scientific, veterinary and field conservation management fields. Members operate in a voluntary capacity, with the exception of the Scientific Officer who is funded by the United Kingdom Department of the Environment, World Wide Fund for Nature (WWF) Africa & Madagascar, and the Commission of the European Union.

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WHITE RHINO IN HLUHLUWE-UMFOLOZI PARK, SOUTH AFRICA - HAVE 800 BEEN "LOST" ?

EXECUTIVE SUMMARY

*African Rhino Specialist Group's Key Issue Report N°1
February 1995*

This key issue report examines the controversy that arose from an article by Fred Bridgland in the Sunday Telegraph on 11 December 1994 where he alleged that:

- An August 1994 helicopter survey of "*Africa's most important rhinoceros reserve*" (Hluhluwe-Umfolozi Park in KwaZulu-Natal, South Africa) "*showed there were 800 fewer white rhino in the Park than previously thought*". (The helicopter counted 1,214 white rhino in 1994 compared to the previous 1991 line transect derived population estimate of 2,000) Bridgland supported this allegation by referring to the gut-feel of some experienced game rangers who believed that a maximum of only 8% to 11% of the white rhino could have been missed during the 1994 helicopter count.
- The recent CITES convention was led to believe there were more rhino in South Africa than there actually were, implying that South Africa almost fraudulently obtained its downlisting of its white rhino population.
- The helicopter count had been "covered up" as it had not been made public or used to update figures presented at CITES when South Africa's white rhino downlisting proposal was discussed.

This key issue report investigates these allegations by:

Summarising the case presented by the media and some game rangers for there being far fewer white rhino in Hluhluwe-Umfolozi park than previously claimed.

Reviewing the factors that could have affected the bias, accuracy and precision of the 1994 helicopter count. The key question addressed was "*What fraction of the population was the helicopter likely to have missed (i.e. not counted) in the Park?*"

Examining the line transect method which has been the primary technique used to produce white rhino population estimates in the Park since 1986.

Presenting and discussing the results of the 1991 and 1994 line transect programmes. (The latter estimate only became available on 21 December 1994 - after Fred Bridgland had written his original article).

Drawing conclusions based on a review of the scientific evidence as to whether the true population size is most likely to be closer to the Natal Parks Board's official 1994 estimate of 1,800, or the 1,214 counted on the 1994 helicopter count. This indicates and clarifies whether CITES was misled or not, as well as assessing the gut-feel of the game rangers that they saw almost all the white rhino from the helicopter.

Determining whether there was evidence of a deliberate cover-up of the 1994 helicopter count by the Natal Parks Board (NPB).

The review indicated that:

Helicopters seriously undercount most species of animals; and that this undercounting bias increases as the woody vegetation becomes denser (ie poorer visibility), flight speed and strip width increase, and the fewer and less experienced the observers.

Earlier, research in study areas within the Park, which compared the numbers of white rhino seen during helicopter counts with those known to be on the ground, and results from studies in other areas, suggested that in the relatively densely-vegetated Hluhluwe-Umfolozi Park the helicopter probably missed between 25% and 40% of the white rhino. While correction factors will not remain constant from year to year, using these figures to correct the 1994 helicopter count total for undercounting bias gives a 1994 population estimate in the range of 1,620 to 2,103. (The review, however, did indicate that in more open areas with better visibility a helicopter may only miss 9% to 24% of the white rhino.)

Line transect density estimation has a number of advantages over single helicopter counts, the most significant of which is that the method uses distance data collected during fieldwork to estimate the fraction of the population not seen during the survey. This produces an estimate of true population size as opposed to a minimum index. The line transect method also enables estimate precision to be quantified, and unlike helicopter counts, estimate bias is theoretically not affected by changing observers and visibility in different years. The line transect method also provides better population estimates for a wide range of game species. It is for these reasons that the line transect method is preferred by the NPB over helicopter counts.

The NPB's estimate for the Hluhluwe-Umfolozi Park for 1994 based on the line transect method and using a conservative extrapolation for the 30% of the Park without "cut" lines (Wilderness area) was 1,800. Further analysis by the African Rhino Specialist Group (AfRSG) used 1994 NPB helicopter and fixed-wing white rhino distributional data to derive an improved wilderness area extrapolation. This gave a best-estimate of 2,077 white rhino with an approximate 90% confidence interval from 1,714 to 2,441.

Further evidence that the population in the Park has not declined came from an examination of trends in count totals and population estimates from three different methods (line transect, helicopter & fixed-wing). All three methods showed the Park's population of white rhino has increased since the early 1980's when large numbers were removed during a bad drought.

The review also notes that:

Contrary to media allegations, the minimum helicopter count total was (along with the removals and recent drought) taken into consideration when the AfRSG provisionally revised the Hluhluwe-Umfolozi total down from 2,000 to 1,800 (before the 1994 line transect results were available). This figure of 1,800 was used by the AfRSG when drawing up the South African country total of 6,376 used at CITES.

Fred Bridgland was informed of the helicopter count on an official visit to Hluhluwe-Umfolozi. The "lower than expected" 1994 helicopter count was also mentioned by a senior NPB official at an International Symposium "Rhinos as game ranch animals" (held approximately two months before CITES).

Given the advantages of the line transect method, and the problems in accurately interpreting raw helicopter count totals, the NPB was justified in awaiting the results from its line transect programme before releasing its 1994 white rhino estimate for the Park.

(iii)

While we do not know the exact number of white rhino in the Park; based on the evidence and the known factors affecting the performance of the techniques used, the AfRSG concludes that:

- The media and authors of the 1994 helicopter count report⁶⁴ largely did not consider the opinions of professionals in the field of population estimation; and in particular glossed over the major problems which affect the interpretation of single total-area-coverage helicopter counts and the advantages of the line transect method. Prior to writing their original articles Fred Bridgland and Sue Armstrong (New Scientist) were also made aware by the AfRSG of many of the issues discussed in this report, but unfortunately chose largely to ignore the advice given.
- The recent helicopter survey did NOT "show" there were 800 fewer white rhino in Hluhluwe-Umfolozi Park than previously thought.
- The gut-feel of some experienced game rangers on the ground that only a few white rhino were missed from the helicopter was NOT supported by the evidence.
- The population is likely to be closer to the official 1994 NPB figure of 1,800 than the minimum helicopter count total of 1,214. Indeed our further analysis suggests that 1,800 is a conservative estimate. The fact that a number of different methods estimate the population to be around 2,000 to 2,100 adds weight to this conclusion.
- The population has not dramatically declined.
- CITES was NOT misled. Rather, CITES would have been misled had the helicopter count figure of 1,214 been used instead. This figure is simply a minimum number, and is not a credible estimate of the true numbers of white rhinos in the Park.
- There was no cover-up of the helicopter count as alleged.
- The controversy of "800 missing white rhino" is a non-story, as the evidence does not support either this assertion, or the other related insinuations and allegations that followed the publication of Fred Bridgland's original article.

INTRODUCTION

This key issue report examines the controversy surrounding conflicting estimates of the current numbers and trend of the white rhino population in Hluhluwe-Umfolozi Park in KwaZulu-Natal, South Africa. The controversy, which arose from an article by Fred Bridgland in the Sunday Telegraph on 11 December 1994, centres on the interpretation of a recent helicopter survey that counted 1,214 white rhinos in the Park. By assuming that this count was fairly accurate, the conclusion was drawn that there were "800 less" than the 2,000 reported earlier by the Natal Parks Board (NPB). The allegation that the helicopter count "showed" there to be "substantially fewer rhino than previously thought" resulted in speculation, and a number of allegations which appeared in the original article and subsequent media reports. The most serious of these were that the news of the "decline" had been covered up; and that as a result the recent Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) had been misled as to the true status of the southern white rhino population during the debate on South Africa's white rhino downlisting proposal.

However, conservation scientists are adamant that the figure of 1,214 has no credibility as an estimate of the actual number of rhinos. They argue that there is strong evidence that the true population of rhinos will be substantially higher and most probably in the region of 1,800 to 2,100.

In view of the potentially-damaging and divisive nature of some of these media reports, the African Rhino Specialist Group (AfRSG) undertook a detailed assessment of the facts. This involved an in-depth scientific review of the population estimation methods used by the NPB, and the interpretation of a number of counts conducted over the past ten or more years. While many of the technical details of this investigation are not presented here, we do highlight the strengths and weaknesses of the various methods, thereby drawing conclusions as to their likely accuracy. We also provide further evidence that contributes to resolving the issue.

Report Structure. This key issue report starts by summarising the case presented by the media and some game rangers for there being far fewer white rhinos in Hluhluwe-Umfolozi than previously

claimed. This is largely in the form of a number of statements that have appeared in the written and spoken media which initially sparked, and later fuelled the debate.

The main body of the report summarises the AfRSG's review of the evidence concerning the interpretation of single white rhino helicopter counts. This is followed by a brief description of the line transect method, and some of its advantages/disadvantages. The results of the 1991 and 1994 Hluhluwe-Umfolozi line transect programmes are then presented and discussed. Finally the 1994 fixed-wing count of the Park is interpreted.

Conclusions are then drawn based on the review of the scientific evidence as to whether the true population size is most probably closer to the Natal Parks Board's official estimates (2,000 in 1991, 1,800 in 1994) or the 1,214 counted on the recent helicopter count. While certain conclusions are drawn by the AfRSG, readers are urged to make up their own minds based on the available information.

The report ends with discussions concerning:

- i) whether there was a cover-up of the helicopter count,
- ii) whether CITES was misled, and
- iii) whether the population has declined, and especially if poaching could have been responsible for a "decline".

Readers wishing to have technical queries answered in more detail are requested to contact the AfRSG Chairman.

BACKGROUND - WHITE RHINO MANAGEMENT IN HLUHLUWE-UMFOLOZI PARK

The Hluhluwe-Umfolozi Park is a fenced 965 km² protected area, comprising a mosaic of open grasslands, acacia savanna, woodlands and forest. The management authority is the Natal Parks Board. By 1900 the last remaining 10-20 southern white rhinos (*Ceratotherium simum simum*) were restricted to this area, and it is from this nucleus that the current African population of over 6,700 and another 640 in captivity worldwide were derived through translocation exercises undertaken since 1961. To date over 3,800 white rhino have been moved by the Natal Parks Board from

Hluhluwe-Umfolozi Park alone⁴¹. This rescuing of the southern white rhino from extinction has been recognised as one of the world's great conservation success stories.

The 1991 estimate for white rhinos in Hluhluwe-Umfolozi derived from line transect sampling was 2,000 (1,988 rounded: 90% confidence interval around estimate \pm 20.1%). Thereafter simple extrapolation was used to derive the annual estimates until the line transect survey was repeated in September/October 1994. The official 1994 Natal Parks Board estimate of 1,800 was released on 21 December after the line transect data had been analysed by the Park's Regional Ecologist.

Current management restricts removals to low density "sink" areas mainly situated on the periphery of the Park. This strategy maintains the population below carrying capacity and simulates the "natural" population regulatory process of dispersal⁴². This has security advantages, and by keeping the population below carrying capacity ensures a high population growth rate. By creating low density zones, dispersal can still occur as rhino numbers build up in other areas in the fenced Park. The white rhino population is also afforded some protection against mass mortality that could otherwise occur at high densities during prolonged droughts (i.e. in the absence of dispersal)⁴².

Intensive security measures costing US\$ 1,000 /km²/annum⁴³ have limited white rhino poaching to 25 animals over the last five years (1990-94), with most offenders being apprehended and charged.

The 1994 helicopter count referred to by the media was conducted in August 1994 by the Conservator for Umfolozi and a consultant game ranger⁴⁴.

THE CONTROVERSY OF THE "MISSING RHINOS" - AND RELATED CONCLUSIONS

A British journalist, Fred Bridgland, started the controversy when he wrote in the British Sunday Telegraph⁴⁵ that "a survey of Africa's most important rhinoceros reserve shows their numbers have fallen dramatically" and that this "means the animal is nearer to extinction than previously thought."

In mentioning South Africa's recent downlisting of its white rhino population from Appendix I to Appendix II for live sales at the recent CITES

convention, he went on to write that "*what the delegates...didn't know is that an unpublished survey*" (of Hluhluwe-Umfolozi Park) "*shows there are 800 fewer than the 2,000 animals claimed to be there*".

His "missing 800 rhino" argument was based on a comparison of the recent total-area helicopter survey of the Park, which counted 1,214 animals, with the 1991 population estimate of 2,000.

On Radio South Africa, Bridgland also said that "*the rhino is now under colossal assault in South Africa itself, and the South African Park authorities are not really giving the full facts to the public*".

In offering an explanation as to why white rhino numbers "*have fallen dramatically*" Bridgland said on radio that "*the Park officials are saying it is due to faulty counting in the Park*" but it "*does mean there has to be a drastic revision of the numbers of rhino in South Africa*", and that "*certainly the wild population of African rhino is being reduced by one tenth as a result of this discovery*".

He went on to note that there was poaching going on in the Park at the moment, and "*this is getting very little publicity*".

When asked on radio if the Natal Parks Board were covering up, Bridgland replied that "*at a very senior level of the Parks Board they are covering up to the extent that no official announcement has been made...telling the South African public that they have 800 less white rhino than they thought they had*". Bridgland however did say that "*certain officials within the Natal Parks Board were very honest about it, but I mean I discovered it almost by accident. I had gone to talk to people and it kind of slipped out*".

Bridgland questioned the vote at CITES which resulted in the downlisting of the South African population allowing international trade in live white rhino, as the debate was "*based on South African figures showing how animal numbers have increased from the brink of extinction*". Bridgland asked why the helicopter count result "*was not released to the public, or used to update figures for the CITES conference*".

In the New Scientist, Sue Armstrong⁴⁶ also discussed the "*row that has blown up over the figures that were used (at CITES) to justify the (downlisting) decision*". Armstrong wrote that the

helicopter count "suggests the reserve may have 40% fewer rhinos than officials have been claiming"; and repeated the allegations that this "was not made public, nor discussed at the CITES meeting". Indeed the headline to Armstrong's article read "Aerial survey undermines case for rhino trade".

The Environmental Investigation Agency (EIA) widely circulated Fred Bridgland's Sunday Telegraph article that started the controversy with a covering letter stating that the article "provided new information about a recent survey which showed a marked decline in the South African population of white rhino". The EIA circular also noted that the results of the survey were of interest given the recent CITES decision to allow South Africa to sell live white rhino internationally.

Further fuel for the debate came from two experienced game rangers, currently not employed by the Natal Parks Board⁷, who went on record as querying the accuracy of previous estimates. The game rangers quoted had spent many years working in Hluhluwe-Umfolozi and have considerable experience in the operational (as opposed to the analytical) aspects of aerial game counts.

The Game Rangers Association deputy chairman⁷ was quoted as saying that "rangers have for some time doubted the scientists' estimate (of 2,000) as their experience indicated 1,400 at most". He added "You can't be more than 150 animals (11%) out in a helicopter census done in ideal conditions like this one was. The scientists have made a mistake somewhere along the line. I don't know the reason."

The consultant game ranger⁷ went on radio and was later quoted in the New Scientist as believing the count "was accurate to within 100 animals" (8%).

In their report of the Hluhluwe-Umfolozi Park count, the authors⁴ wrote that the total of 1,214 was "a fair and true reflection of what the population stands at present", adding that the count was carried out in "near to perfect conditions", and that if any correction factor was to be applied it "should be minimal". The authors⁴ did not mention previous Park population estimates or work on population estimation in the Park, except to cite one scientific paper⁶ as suggesting "that helicopter counts in Umfolozi account for 100% of the white rhino actually on the ground,

ie., that the raw helicopter count totals should remain uncorrected". They⁴ also indicated that the count result confirmed their gut-feel on the ground. Their report concluded that "the predictable outcome and results of the counts came as no surprise to management staff in the Hluhluwe-Umfolozi Park".

Armstrong⁶ also noted that the count total "tallies .. with the gut-feel of field staff, who say the scientists at head office do not know what is going on in the Park".

Summary: The argument for the "800 missing rhino" is based on the assumption that the helicopter counted almost all the rhino, this being backed up by a "gut-feel" and a reference to one scientific paper.

Key Question: In assessing the "gut-feel" of the game rangers the critical question that needs to be addressed is.. *What fraction of the population of Hluhluwe-Umfolozi white rhinos is the helicopter likely to miss?*

GAME COUNTING IN THE PARK

The bulk of the media debate has centred on the result of the helicopter count undertaken in August 1994.

However, Hluhluwe-Umfolozi's "official" 1994 white rhino population estimate, and indeed the 1986, 1987, 1988 and 1991 estimates, were based on the recognised "line transect" method that has been used throughout the world²⁴. This method has many advantages over single helicopter counts, and this is why it has replaced helicopter counts as the mainstay of the Park's population monitoring programme since 1986. Many readers will not have any idea what a "line transect" is, or involves. For their benefit, a brief description of the method, its basic principles and advantages are given later.

The recent helicopter count is the first helicopter count of the whole Park since 1983. However, helicopters have continued to be used to help estimate population sizes in the 260 km² "wilderness area" of Umfolozi where NPB policy precludes the cutting of line transects.

In recent years, regular fixed-wing aircraft counts have also been routinely used to supplement the line transects and to provide distributional

information, as well as to allow game rangers to search for any undetected carcasses.

Thus, the Park's white rhinos have been monitored using line transects, helicopters and fixed-wing aircraft. All three methods were used in Hluhluwe-Umfolozi in 1994.

HELICOPTER COUNTS

Counting white rhino from a helicopter may appear simple because those in open areas are easily spotted, but an accurate estimate of the actual size of the population depends on knowing how many have been missed. Unfortunately this cannot be done subjectively or by using gut-feel: it requires controlled experimentation.

Factors affecting aerial counts

A review of helicopter counting in numerous areas worldwide indicated that there are a large number of factors that can result in undercounting bias in total-area aerial counts^{#10,11,12,13,14,16,17&21}; and which would have applied to a greater or lesser extent to the total-area helicopter count conducted in Hluhluwe-Umfolozi in 1994. The most important of which are briefly described below.

Intrinsic visibility of rhinos

The visibility of white rhinos from the air depends to a large degree on the woody vegetation density, the behaviour of the animals, the weather, disturbance and topography.

This is illustrated by a Natal Parks Board review of fixed-wing counts^{#10} which showed that by flying Hluhluwe-Umfolozi in mid-winter or late/spring, when visibility is best, consistently produced 20%+ higher white rhino counts compared to late summer counts when visibility is at its poorest. However, at no times of year is visibility perfect, suggesting that some animals will always be missed.

Hluhluwe-Umfolozi is quite different from the open plains of the Serengeti. The Park is hilly and the vegetation often dense, varying from open grassy areas with scattered trees, to thickets, closed canopy woodlands and forests. Visibility is therefore a significant factor.

White rhinos generally prefer the more open areas, but not exclusively so, as two of their most preferred grasses (*Panicum maximum* and *P.deustum*) occur primarily under tree canopies^{#9}. They also rest in thickets or under trees to keep cool. The hotter and drier the conditions the more rhino will be partially or totally obscured by vegetation.

Also, many species exhibit avoidance behaviour in response to helicopters and seek shelter in dense vegetation. Black rhinos react strongly in this way, white rhinos certainly less so, but this could still be a factor.

Flight speed, strip width and helicopter type

These parameters are particularly relevant where most of the area is covered by woodlands, as is the case in Hluhluwe-Umfolozi. Frequent scanning by observers is required to detect animals as observation angles change, and this becomes increasingly difficult as flight speed increases and when wider strips are used. Research has shown that an increasing number of animals are missed towards the edges of strips and directly underneath the aircraft^{#11,12,21,30}; and that more animals are detected when more observers are used^{#12}, which becomes possible when a larger helicopter is used.

Observer Error

Apart from the difficulties outlined above, even experienced observers vary in their intrinsic ability to spot animals; and experienced observers can see up to 60% more than inexperienced observers^{#13}; although this is unlikely to apply to the same extent with white rhino.

The observers used for the Hluhluwe-Umfolozi helicopter count varied in their aerial counting experience.

Inherent variability of helicopter counts

Replicated helicopter counts are rare. However, in two studies^{#14&15} where helicopter counts were repeated a number of times under very similar conditions, the highest and lowest white rhino counts varied by over 30%. Apart from highlighting the fact that a fairly large proportion of rhinos can be missed during a count, it also raises

problems with interpreting a single count - was it a "good" one or a "poor" one? On the other hand if counts are repeated a number of times within a year it is possible to place confidence intervals on the estimate, although the undercounting bias (and variable observer/visibility biases between different year's counts) will still remain^{#15}.

Correcting helicopter totals

There is a body of evidence which indicates that helicopter counts should underestimate the numbers of white rhino on the ground. Because of this, conservationists invariably either (i) use the raw aerial count data as an uncorrected minimum figure (or index), or (ii) apply a correction factor to account for undercounting bias.

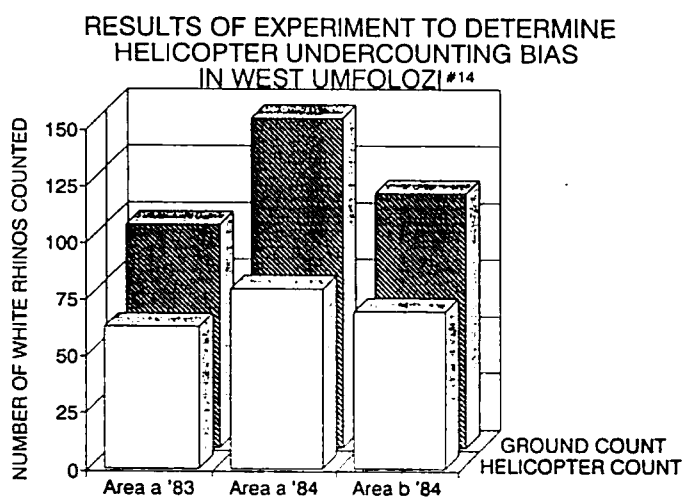
Such correction factors are usually established by comparing the numbers of rhino counted by the helicopter in selected study areas with those "known" to be on the ground (either through recent re-stocking of the area and population modelling or intensive ground counting). So, if the helicopter counted only 75% of the rhinos, a correction factor of 1.33 would be applied. However, substantial errors may still occur when the correction factors observed in one area in one year are used to extrapolate over a whole park, or indeed are used to correct counts in subsequent years when conditions (eg observers & visibility) may be different. Corrected helicopter counts are therefore at best approximate estimates of the true population sizes.

Supporting Evidence

Undercounting bias

● In Hluhluwe (1983) 30 white rhino were counted in seven game counting blocks (22.4 km²) using foot-based drive counts. A helicopter count of the same blocks recorded 22 white rhino, indicating an undercounting bias of 27%^{#17}.

● In Umfolozi (1983-84) in a bigger study^{#14} using the same approach, the helicopter recorded 210 of the ground total of 355; indicating an undercount of 41%. The results are shown graphically in the following figure:



● Pilanesberg National Park, South Africa (1994).

Annual helicopter counts have been undertaken in the 550 km² Park to monitor trends in key game populations, including the reintroduced white rhino population. To estimate possible helicopter undercounting bias, the annual minimum helicopter counts were compared with the estimated population sizes over the years. The latter were derived from modelling known introductions, mortalities, numbers harvested, age and sex survey data, and known white rhino growth rates under different rainfall years^{#18}. The results of this comparison indicated that in most years the helicopter missed approximately 10% to 20% of the white rhino population in the Park. However, as the Pilanesberg vegetation is more open than Hluhluwe-Umfolozi, and the helicopter is flown lower and slower than in the recent Hluhluwe-Umfolozi count, the professional ecologist concerned^{#18} felt this would suggest that in all probability at least 25% and probably 30%+ white rhino would be missed in the more densely vegetated Hluhluwe-Umfolozi Park.

● Pongolapoort Biosphere Reserve, South Africa (1990-94). In an approximately 30km² fenced area of the Reserve the white rhinos are individually known, and from 1990-94 their numbers have varied from between 10 and 17 animals. During this period ten helicopter counts conducted in the area undercounted the population by an average of only 9%^{#19}.

This high degree of accuracy indicates what can be achieved under near ideal conditions: the white rhino concentrate in a 10 km² area where there is little dense vegetation to hide them; recent counts

were conducted slowly, flying only took place during the best hour or so of the day; and the observers were always fresh as the whole area can be counted in part of a morning^{#19}.

In contrast, the 1994 Hluhluwe-Umfolozi count extended over about 4 hours/day for 5 days, and ground coverage was fast, and the vegetation denser. This will have increased sensory overload and fatigue^{#20}.

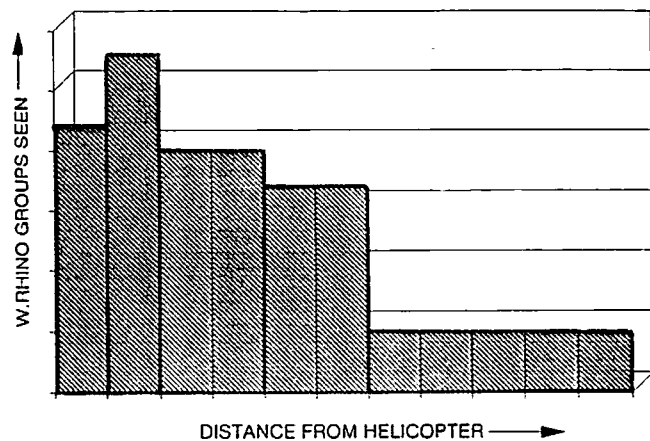
● Umfolozi (1978). The only scientific paper^{#6} cited by the authors of the 1994 helicopter count report was found to be seriously flawed, as the ground count method used was such that many white rhinos will have been missed. The ground estimate was obtained by a team of two observers who walked through every 500m x 500m grid square in the study area searching for animals. According to two observers^{#22} who have repeated the exercise with the paper's author a number of times, the average strip width averaged about \pm 250 m either side of the route being walked. However, in places, visibility was often substantially less than this (sometimes even less than 15m) due either to the terrain or thick bush. Thus a substantial part of the study area was effectively not surveyed using this method. The ground count results will therefore have produced inaccurate under-estimates of the true numbers of white rhino, and therefore did not provide a suitable baseline against which helicopter counts could be directly compared to estimate undercounting bias. The paper's conclusion that the helicopter counted all the white rhino present was therefore not based on valid evidence.

Flight speed, strip width and helicopter type

● Research in 650 km² Madikwe Game Reserve (1994), South Africa^{#21}, demonstrated that fewer rhinos were seen within 50m of the helicopter than at 50-100m away, suggesting movement away from the helicopter or that white rhinos close to the flight path were more easily missed. Few white rhino were seen beyond 300m.

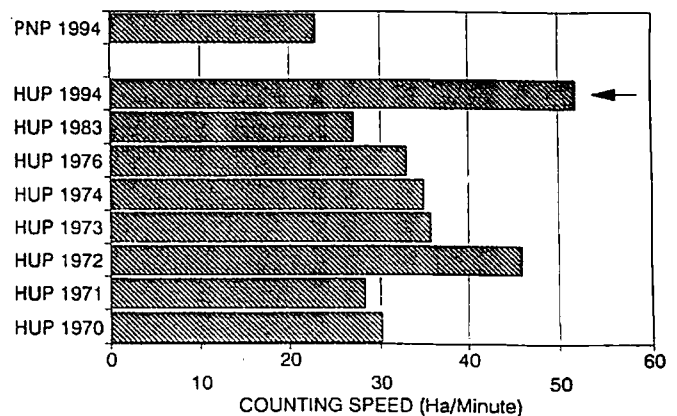
A minimum 14% to 24% of the white rhinos in the first 250m either side of the helicopter (same as the strip width used in the 1994 Hluhluwe-Umfolozi count) were missed. The visibility in the areas where the white rhinos occur in Madikwe is better than in Hluhluwe-Umfolozi^{#18}, and so the expected undercounting bias in the latter will be greater.

FREQ. DISTRIBUTION OF W.RHINO GROUPS SEEN AND DISTANCE FROM HELICOPTER #21



● The following figure indicates that the recent helicopter count covered the ground substantially faster than in previous Hluhluwe-Umfolozi (HUP) counts^{#4,17}. Counting speed was double that currently used in the more open Pilanesberg National Park^{#18}. As discussed earlier, this is likely to result in more rhinos being missed, so the count conditions may not have been as ideal as claimed by the game rangers^{#7}. Unfortunately this also makes comparison with previous Hluhluwe-Umfolozi helicopter counts difficult.

HLUHLUWE-UMFOLOZI PARK/PILANESBERG N.P. HELICOPTER COUNTING SPEEDS (Ha/Minute)



Based on Data in Knott A.P. (1983), Conway A.J. & P.M. Hinchins (1994) & K. Adcock (pers.comm.)

● The change in helicopter at Rooiport, South Africa from an Aerospatiale Squirrel with three dedicated observers, a pilot and two dedicated data recorders, to a bigger Aerospatiale Dauphin with two additional observers significantly increased the number of sightings obtained^{#12}. This indicated that the greater the number of observers the lower the

undercount, and that individual observers therefore must be missing animals. Results from the Madikwe experiment^{#21} showed a similar trend when fixed-wing aircraft counts using different numbers of observers were compared.

However, even when using the big helicopter, and considering Rooiport has better visibility than Hluhluwe-Umfolozi, the density of sightings of game species still declined as distance from the flight path increased, indicating animals were being missed towards the edges of strips^{#21}.

Both helicopters used at Rooiport had more dedicated observers and were bigger than the four seater Hughes 500 helicopter used in the 1994 Hluhluwe-Umfolozi count. In the Hluhluwe-Umfolozi count^{#4} there were only 2-3 observers and the pilot. Unlike at Rooiport, there were no dedicated data recorders on board, as one observer had to double as the main data recorder. One could therefore expect the Hluhluwe-Umfolozi count in denser bush to miss more animals than in the more open Rooiport with more observers. This indicates the Hluhluwe-Umfolozi count conditions could not have been regarded as "ideal".

Variability

In a previous section, the large inherent variability of aerial counts was discussed. Based on the results of experiments where helicopter counts were repeated (while trying to keep counting methodology as similar as possible), the results indicated that 95% of the time any two white rhino counts could be expected to vary by as much as 28% purely by chance^{#15}. In two studies^{#14&15} the biggest count was more than 30% higher than the lowest count; despite trying to repeat the counts "as identically as possible".

If one assumes that all but 8-11% of the white rhino are seen from the helicopter (as suggested by the game rangers) then one cannot explain the much larger differences between replicate counts that can occur, as being primarily due to variable undercounting (logically the most likely cause). Instead one needs to infer large and variable overcounting. However, this doesn't tally with how white rhino's react to helicopters. Double counting has never been recognised as a problem before, and the 1994 count report^{#4} supported this view.

Logically if one counts almost all the white rhinos, and white rhinos are not subject to large scale double counting, then replicated counts should vary much less than they actually do. The observed variability of replicated helicopter counts (in cases over 30%) therefore logically supports the conclusion that the true population sizes are much higher than the minimum number counted.

Summary: The above review indicates that in all probability, the 1994 Hluhluwe-Umfolozi helicopter count probably missed between 25% and 40% of the white rhino in the Park. This translates to a population estimate of between 1,620 and 2,020. However, given the problems with corrected single helicopter counts, this simply gives an approximate estimate of numbers.

The evidence indicated that under more open conditions and hence better visibility, a helicopter may only miss 9% to 24% of the white rhino. However, this level of undercounting bias should not be extrapolated to areas with poorer visibility like Hluhluwe-Umfolozi where a greater fraction of the population will be missed.

The review also shows that the 1994 Hluhluwe-Umfolozi helicopter count conditions were perhaps less than the ideal claimed (small variable number of observers [2-3], fast coverage & observers with a range of experience). In using the words "ideal conditions" the count report authors^{#4} were presumably referring to the weather conditions during the count.

Fred Bridgland's claim that the helicopter count "showed there to be 800 fewer animals", and that the population was therefore very close to the count total of 1,214 is clearly not supported by the evidence. What has been presented to the public as fact, clearly isn't. The evidence also does not support the game rangers gut-feel that they only missed 100 to 150 animals during the recent count.

While we cannot be sure of the exact population, the evidence does strongly suggest the population is closer to the 1994 official estimate of 1,800 (the same figure as used in drawing up the South African country total) than the minimum count total of 1,214.

While the actual counting of animals from a helicopter may be relatively straight-forward, we have seen that the interpretation of the number counted in single helicopter counts is fraught with

problems and many factors have to be considered. Due to this multitude of problems, single helicopter counts are simply not very good for accurately estimating white rhino population sizes.

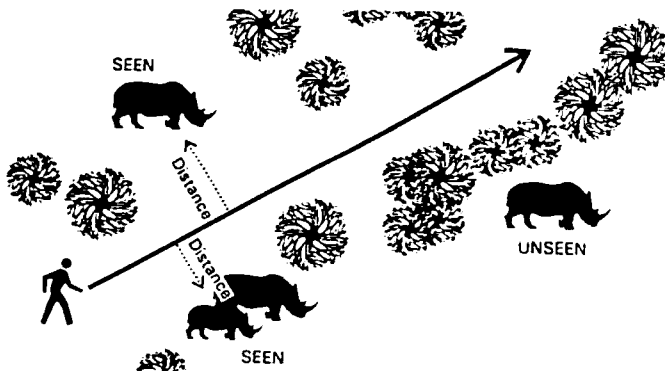
It is precisely because of all the problems (some of which have been listed above) that a specialised branch of conservation science and statistics has developed which deals with population estimation. Specialists in this field invariably have had many years of applied scientific/statistical training and experience, which is coupled with field and counting experience. It is also because of the difficulty in accurately estimating animal numbers worldwide, that conservation organisations hire professional scientific staff, to amongst other things, produce and interpret population estimates.

LINE TRANSECT POPULATION ESTIMATION

A number of applied statisticians around the world have been working for decades in an attempt to improve population estimation methods. The group of density estimators of which the line transect method is one²⁴, is a product of this research.

The method

The term "line transect" refers to a population estimation technique where observers move along a straight line while counting animals and recording their location relative to the line. The technique assumes that all the animals are seen on or near the line, but that the further away from the line one looks, an increasing number of animals will go undetected because they are hidden by vegetation. To minimise the chance of disturbing animals on the line, observers in Hluhluwe-Umfolozi walk slowly along 1-2m wide "cut lines" which have been cleared through the bush.

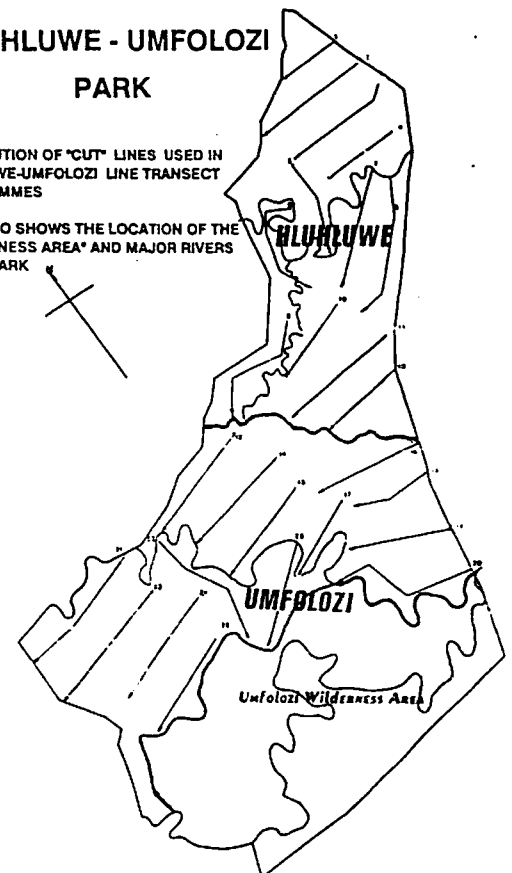


The "cut lines" are spread evenly throughout about 70% of Hluhluwe-Umfolozi Park (see below). The remainder of the park is a 260km² "wilderness area" where policy precludes cutting lines, and a different method has to be used to estimate rhino numbers in this area. Providing the sample of all lines is representative of the area as a whole it does not matter that they will pass through a range of different habitat types. Each "cut" line is about 8 km long; and over a six-week period in 1994 all but two lines were walked 14 times, giving a total sample of 2,948 km walked (39% more than in 1991). A total of 534 white rhino groups were seen during the 1994 survey.

HLUHLUWE - UMFOLOZI PARK

DISTRIBUTION OF "CUT" LINES USED IN HLUHLUWE-UMFOLOZI LINE TRANSECT PROGRAMMES

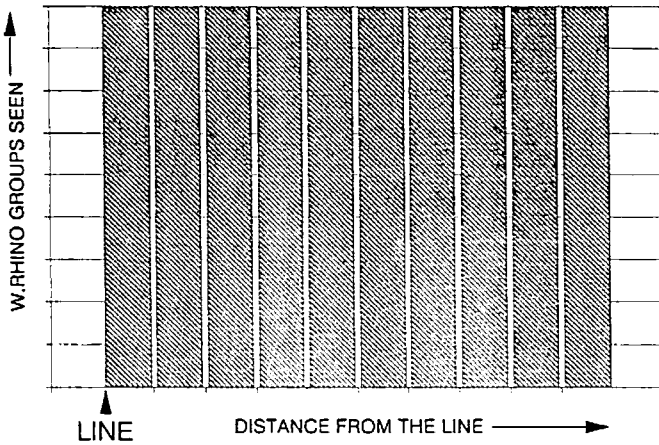
MAP ALSO SHOWS THE LOCATION OF THE "WILDERNESS AREA" AND MAJOR RIVERS IN THE PARK



Data analysis

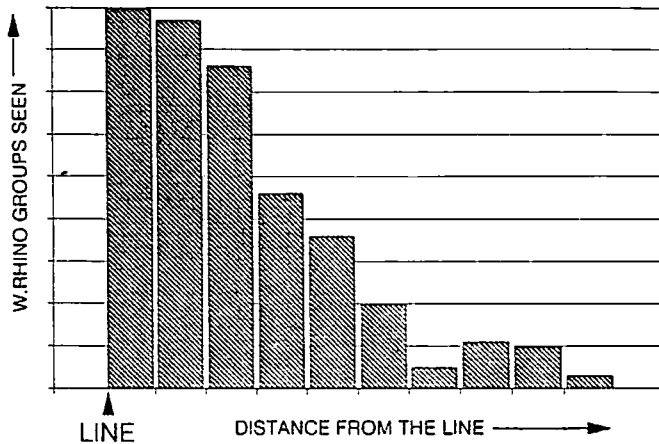
The data analysis is primarily concerned with examining the relationship between the number of animals seen and distance from the line. In the unlikely event that all rhino were seen during a survey (i.e. none are missed), a sighting/distance graph would look like the figure overleaf..

EXPECTED SIGHTING/DISTANCE GRAPH IF ALL WHITE RHINOS ARE SEEN



However, in reality one will miss increasing numbers of animals further from the line, and the sighting graph could look something like this..

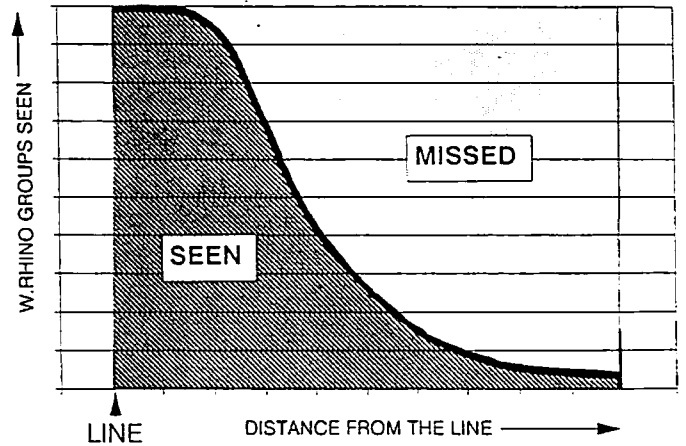
HYPOTHETICAL SIGHTING/DISTANCE GRAPH FOR WHITE RHINO



This pattern is usually a little messy as the data are a sample. To derive the best estimate of the relationship between the chance of sighting groups and distance from the line, a curve is then mathematically fitted to the data as illustrated. Much work has gone into producing a range of mathematical models that work well in theory and practice^{#24}.

The key concept to grasp behind line transects is that (assuming you don't miss animals on or near to the line) the proportion of the population one has seen during the survey (dark shaded area) can be estimated using the distance data.

SIGHTING/DISTANCE CURVE FITTED TO HYPOTHETICAL WHITE RHINO DATA



As we can estimate the proportion seen, we therefore also can estimate how many rhino we probably missed (light dotted area).

The line transect method therefore uses the sighting distance data to automatically "correct" the number of rhino seen during the survey to produce an estimate of the true number of rhinos (ie both seen and unseen). In essence, the principle behind line transects is similar to applying a correction factor to raw aerial counts to produce an estimate of the true population. For a detailed background and explanation of these methods interested readers are referred to the book on Distance Sampling by Buckland *et al*^{#24}.

Advantages of line transects

The line transect method is robust, and overcomes many of the problems inherent with single helicopter counts.

- Unlike helicopter counts, it produces an estimate of the true population size rather than simply just a minimum count (or index).

- As discussed earlier, single total-area helicopter counts are inherently variable, yet unless some form of replication has been adopted, no measure of estimate precision is obtained. By way of contrast the line transect uses the variability between replicated transects to calculate the degree of precision around the estimate produced^{#18,30}.

- Another major advantage of the line transect method over single total-area aerial counts is that automatic "correction factors" are in effect derived for the whole area surveyed.

By way of contrast, to calibrate total aerial counts using more accurate ground-truthing involves extra work, and logistically can only usually be done in small areas. Strictly speaking one is not justified in applying a ground-truthed correction factor derived in a small area of a park to the whole park, unless the conditions are uniform throughout the park. It's better than nothing, but far from ideal.

The undercount "correction" method used in line transect estimation is therefore superior, and should produce a better population estimate than "ground truth" corrected helicopter counts.

- Just as in aerial counts, visibility changes between years and seasons, and different observers vary in ability. In aerial counts this variable bias between counts is a real problem. However, the beauty of the line transect method is that this should not affect the accuracy of the estimate. It simply is automatically taken into consideration, and reflected in different shaped sighting/distance graphs in different years.

- Line transects give better estimates of many smaller antelope species than aerial counts.

For these reasons the line transect programme has been used as the basis of the NPB's monitoring programme since 1986. It is also why the NPB waited until the line transect data had been analysed before announcing their official 1994 estimate.

Disadvantages of line transects

Line transects are not suited to carcass detection and examining spatial distributions of animals in a park. This is better done using other methods such as aerial surveys.

In the real world, no population estimation technique is perfect and without problems. The line transect is no exception²⁵. However, it has fewer problems than single helicopter counts; and the NPB procedure used, attempts to limit the influence of some potential problems²⁵.

However, perhaps the biggest problem with line transects is not with the method itself, but with how

non-scientists who have to use the results perceive the technique. Analysis is complex and mathematical, and is often only really understood by the conservation scientist doing it. To a non-specialist it is perhaps not intuitively obvious how someone sitting in an office using a computer can estimate how many animals were not seen. This can lead to a degree of scepticism about the results, especially if they differ much from "gut-feel".

1991 estimate

The 1991 survey indicated that for the 70% of the Park with line transects, one could be 90% certain that the true population lay somewhere between 955 and 1,437, and most likely it was somewhere near the best estimate of 1,196^{18,20}.

An extrapolated estimate was then made for the wilderness area, as line transects cannot be cut there. This was done by firstly comparing the line transect-estimated density in the rest of Umfolozi to a helicopter count in the same area to derive a helicopter count correction factor. This correction factor was then applied to a helicopter count of the wilderness area to produce a population estimate of 792^{18,20}.

When added to the line transect estimate for the rest of Hluhluwe-Umfolozi, this gave a 1991 population estimate for the whole Park of 1,988 (rounded to 2,000).

Intervening period

In the period between 1991 and 1994 line transect estimates, 399 white rhinos were translocated out of the Park, 10 were poached and at least 108 died from natural causes.

1994 "official" NPB estimate

The 1994 best estimate for the 70% of the Park with line transects was almost the same as the 1991 estimate at 1,208 with a 90% confidence interval from 997 to 1,419²⁰. The 1994 estimate is more precise than the 1991 estimate because of the bigger sampling effort (39% more walked) in 1994. This result does not suggest that the 1991 figure was an extreme outlier (ie was a result of extreme chance sampling).

The "official" wilderness area line transect extrapolation simply assumed that the density of white rhino in the wilderness was the same as the density in the rest of Umfolozi. This assumption is likely to be conservative, as the dispersal sinks where most of the rhino have been removed during the last decade occur in the rest of Umfolozi, and not in the wilderness area. Not unexpectedly, using this conservative assumption resulted in a lower "official" wilderness area estimate of 597.

This gives the official NPB 1994 estimate for the Park of 1,805 (rounded to 1,800)²⁰.

FURTHER ANALYSIS

Modelling from 1991 estimate

Assuming the 1991 estimate was accurate, estimates for 1994 were modelled using the likely range of annual net growth rates (from 4% to 10%) and accounting for removals and known poached animals. This produced modelled population estimates which ranged from 1,803 (4%) to 2,158 (10%).

1994 line transect based estimate using improved extrapolation for the wilderness area

We undertook further analysis of the results by using the 1994 fixed-wing and helicopter counts of the Park to examine the relative density of white rhinos in the wilderness area compared to the rest of Umfolozi.

As expected, both the helicopter and fixed-wing surveys recorded higher white rhino densities in the wilderness area. Taking the average density differential of the two aerial counts to extrapolate a best estimate for the wilderness gives a higher estimate of 869 (711 based on fixed-wing count, 1026 based on helicopter count).

This gives a 1994 line transect based best estimate for the whole Park of 2,077 (rounded to 2,075).

These results indicate that the differences between the "official" 1991 and 1994 estimates is due largely to the use of a more conservative (and seemingly unjustified) assumption that the density of white rhinos in the wilderness area was the same as elsewhere in the Park.

Summary: The results of the recent line transect programme corroborate the 1991 estimate of 2,000, and indicate the current population is most likely to be around 2,075 (90% confidence interval 1,714 to 2,441²⁸)

Fixed-wing aircraft counts

- Data from the ground-truthing-techniques comparison study in western Umfolozi¹⁴ indicated that a fixed-wing aircraft only counted about 42% of the white rhino. Using this information to correct the 1994 fixed-wing count total gives an approximate population estimate of 2,100.

- Data and modelling using fixed-wing count data from Itala Game Reserve²⁶ and Kruger National Park²⁷ together with comparative helicopter/fixed-wing studies^{14,21} also indicated that a helicopter should miss a substantial number of white rhinos in Hluhluwe-Umfolozi Park.

CONCLUSIONS REGARDING NUMBER OF WHITE RHINOS IN HLUHLUWE-UMFOLOZI

The bulk of the evidence supports the argument that the population is likely to be closer to the official Natal Parks Board figure of 1,800 than the minimum helicopter count total of 1,214. Indeed our further analysis suggests that the estimate of 1,800 is a conservative one. The fact that a number of methods estimate the population to be around 2,000 adds weight to this conclusion.

WAS THERE A COVER-UP OF THE HELICOPTER COUNT ?

- The above review indicates that as the Hluhluwe-Umfolozi population is in all probability similar to the official Park estimates; and as correcting the minimum helicopter count total for probable undercounting bias produces a similar figure, there is really nothing to cover-up.

- There is nothing to suggest that the Natal Parks Board have been anything but open in their dealings:

- Fred Bridgland's visit to Hluhluwe-Umfolozi prior to writing the Sunday Telegraph article was sanctioned by the NPB. The results of the count

were freely given.

- The "lower than expected" recent helicopter count total was mentioned by a senior Natal Parks Board official²⁹ at an International Symposium (open to the public and press) entitled "Rhinos as game ranch animals" prior to the recent CITES convention.

- The AfRSG requested and received a copy of the count report before CITES.

- The NPB was justified in awaiting the results of the 1994 line transect survey before releasing updated figures, as the raw helicopter count total could not be accurately interpreted.

WAS CITES MISLED ?

The debate at CITES concerned the status of white rhino in the whole of South Africa. Therefore no individual park totals were presented at CITES (except through documentation submitted by South Africa in mid 1994).

The AfRSG however did verbally present the official South African country total at CITES, and the Hluhluwe-Umfolozi component of this total was 1,800 (not 2,000 as alleged in the media). The AfRSG took the recent helicopter count, and especially the higher level of removals during the recent droughts, into account when provisionally revising the 1991 Hluhluwe-Umfolozi estimate of 2,000.

At CITES, delegates were therefore given a South African country total (6,376) which contained a reasonable population estimate for the Hluhluwe-Umfolozi Park. The IUCN's review of South Africa's downlisting proposal prior to CITES also used the same country total. The decision at CITES was therefore based on sound information.

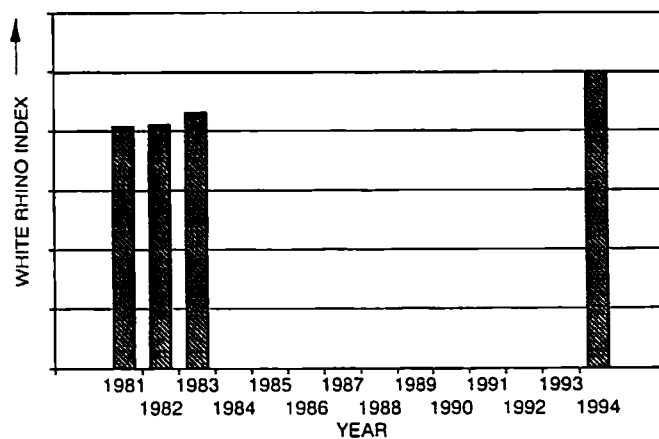
To have used the minimum helicopter count of 1,214 instead of 1,800 as an estimate of the true Hluhluwe-Umfolozi population size would have had no scientific credibility, been contrary to the evidence, and simply would have misled CITES.

HAS THE POPULATION BEEN DECLINING?

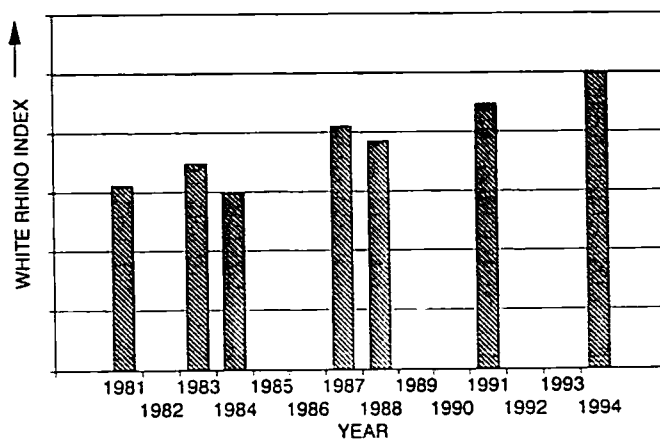
Trends over time

If one plots either fixed-wing counts, helicopter counts or line transect estimates over time (see figures below) the same pattern emerges - that the population has been increasing since the early/mid 1980's. At worst numbers have possibly stabilised/marginally declined in recent years in response to the heavy removals and recent drought.

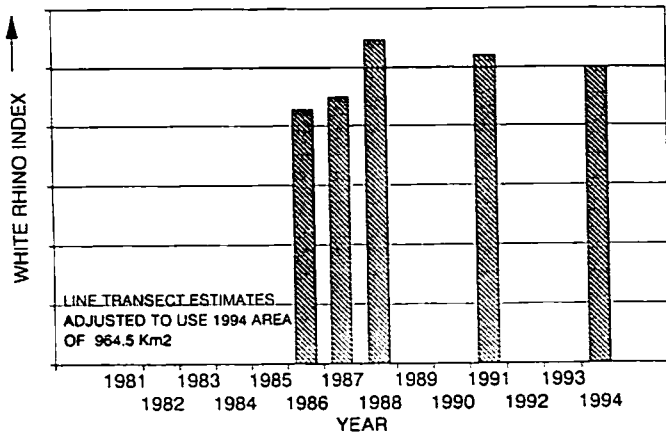
HLUHLUWE-UMFOLOZI HELICOPTER COUNT INDICES (RELATIVE TO '94 COUNT)



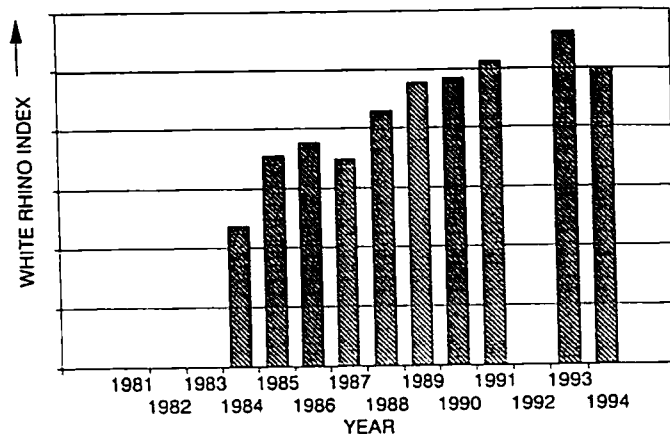
UMFOLOZI (S.ofBik.Umf.River) HELICOPTER COUNT INDICES (RELATIVE TO '94 COUNT)



HLUHLUWE-UMFOLOZI LINE TRANSECT INDICES (RELATIVE TO '94 COUNT)



HLUHLUWE-UMFOLOZI FIXED-WING COUNT INDICES (RELATIVE TO '94 COUNT)



Why poaching cannot be the cause of the "decline"

In the three year period between the 1991 and 1994 line transect programmes 10 white rhino are known to have been poached compared to 108 recorded natural mortalities and 399 live removals.

The average number of white rhinos that have recorded as poached per year since 1990 (5 year period) is 5 which is only a fraction of the annual recorded number of births and deaths.

The Natal Parks Board has an active anti-poaching intelligence network, and if poaching was increasing dramatically it would have been detected. The fact that most rhino poaching offenders in Hluhluwe-Umfolozi to date have been apprehended and charged is testament to the quality

of the game rangers' anti-poaching efforts and the intelligence network.

With regular fixed-wing counts and the recent helicopter count one would have expected to see poached carcasses all over the bush had poaching increased dramatically. The line transect estimates and aerial counts over time should also have revealed such a decline, which they didn't.

Thus there is no evidence that widespread poaching could have contributed to the "decline". Rather, by managing the population at a productive level and preventing it building up to carrying capacity, the Natal Parks Board has contributed to increasing the numbers of rhino in Africa and providing a big buffer against future poaching threats.

Finally, Fred Bridgland claimed the (limited) poaching was getting very little publicity. In fact, the Natal Parks Board has put out a press release every time a rhino has been poached in any of its reserves.

WERE THE BRIDGLAND AND ARMSTRONG ARTICLES BALANCED AND FAIR ?

Before writing their articles, Bridgland and Armstrong were made aware by the AfRSG that using a figure of 1,214 as a population estimate had no scientific credibility as it only represented a minimum number and not a population estimate; and that their "story" was premature as they should wait for the results of the line transect programme. Bridgland and Armstrong were also informed that there was a substantial body of evidence that showed helicopters invariably miss large numbers of animals.

The media has largely reported the views of a few people who are not professional experts in the field of population estimation, and took their opinions at face value, whilst almost completely ignoring the opinion of professional experts. It is unfortunate that the New Scientist article⁶⁶ largely ignored the science behind the issue being reported.

On the basis of the evidence in this review readers are asked to judge for themselves whether the articles were balanced and fair; or whether this was a case of the old media adage of "not letting the facts get in the way of a good story"

CONCLUSIONS

- CITES was not misled.
- There was no cover up.
- The helicopter count did not "show" that the Hluhluwe-Umfolozi population was substantially less than previously thought. The evidence indicates the true population size is most probably close to the 1994 official estimate; and probably a little bigger.
- The population in the Park is not declining, but rather has been managed well by using dispersal sink removals to keep the population in a productive state.
- The "controversy of the 800 missing rhino" is in reality an unfounded "storm in a tea-cup" that arose because Fred Bridgland, Sue Armstrong and the authors of the 1994 helicopter count report didn't take into account the wealth of evidence which indicated a substantial proportion of white rhinos were likely to have been missed from the helicopter; with the consequence that the count total of 1,214 was misinterpreted.

ACKNOWLEDGEMENTS

The AfRSG would like to thank Keryn Adcock, Tony Bowland, Berty van Hensbergen, Kay Hiscoks, Karel Landman, Ant Maddock, Keith Meiklejohn, Trevor Morley, Danie Pienaar, Simon Pillinger and Derek Potter for providing information and results used in this report. Keryn Adcock and Berty van Hensbergen are especially thanked for their comments on population estimation in general; and the use of helicopters and line transect density estimation methods in particular; and for allowing us to use their work prior to publication. Also, particular thanks must go to Ant Maddock and Keryn Adcock for supplying all the information about current and past population estimates in the Park. Heidi Snyman is also thanked for helping produce a Correl-Draw figure for the report. We also would like to acknowledge the authors of Buckland *et al* (1993)²⁴ for the neat graphical way they chose (and the AfRSG has used in this report) to explain the basic concept behind line transect density estimation. Finally the AfRSG would like to thank all those who proof read and commented on earlier drafts of this report.

NOTES & REFERENCES

- #1 Keith Meiklejohn (Natal Parks Board Head of Game Capture) pers. comm. To date NPB game capture has moved a total of 4,173 white rhino from all its reserves. All are originally descended from Hluhluwe-Umfolozi stock.
- #2 Owen-Smith R.N. (1982) Dispersal and the dynamics of large herbivores in enclosed areas: implications for management. In Management of large mammals in African conservation areas (ed R.Norman Owen-Smith) 127-144 Haum, Pretoria
- #3 Conway A.J. (1993) Costing: To run a medium-sized (60,000 ha) Game Reserve *Unpubl. NPB Memorandum* 3pp.
- #4 Conway A.J. & P.M. Hitchins (1994) Square-lipped rhinoceros Hluhluwe-Umfolozi Park helicopter count : 24-31 August 1994 *Unpubl. NPB report* 6pp + Appendices
- #5 Bridgland Fred (1994) How South Africa "lost" 800 white rhino *Sunday Telegraph* 11 Dec. 1994
- #6 Armstrong Sue (1994) Aerial survey undermines case for rhino trade. *New Scientist* 24/31 Dec. 1994 p10
- #7 Mr Peter Hitchins (Consultant Game Ranger, Chairman of the Game Rangers Association of Africa, co-founder of the Rhino and Elephant Foundation and noted rhino conservationist) and Mr John Forest (Ex-warden of Umfolozi and Deputy Chairman of the Game Rangers Association of Africa).
- #8 Melton Derek A. (1978) Undercounting bias of helicopter censuses in Umfolozi Game Reserve. *The Lammergeyer* 26: 1-6
- #9 Emslie Richard H. (1985) Resource partitioning between the five major grazing ungulates in the Umfolozi Game Reserve, Natal. Paper presented at the Zoological Society of Southern Africa's symposium on Competition and Coexistence - Abstract- *Sth Afr. J. Sci.* 81: 698-699. Also quoted by Jarred Diamond in *Nature* (1985).
- #10 Adcock Keryn (1990) Preliminary results of the fixed-wing censuses from 1981 to 1990 *Unpubl. NPB report* 15pp.
- #11 Caughley G. (1974) Bias in aerial survey. *J. Wildl. Mgmt.* 38: pp921-923
- #12 van Hensbergen H.J., M.P.S. Berry & J. Juritz (1995) Helicopter based line transect estimates of African herbivore populations. 15pp. *Unpublished manuscript* being submitted for publication.
- #13 Watson R.M., G.M. Jolly & A.D. Graham (1969) Two experimental censuses. Proceedings of workshop on "The use of light aircraft in wildlife management in East Africa" *E. Afr. Agric. For. J.* 35 Special Issue.
- #14 Kuott A.P. and P.M. Brooks (1986) An evaluation of helicopter and fixed wing censusing in Umfolozi Game Reserve *Unpubl. NPB report* 15pp

Animals were counted on the ground by sweeping study areas using a 1.5 km wide U-shaped human net of people to record animals that passed through the "net" or seen moving off in

front of the two side wings of the "net". Each population estimate was obtained by adding up the rhino counted on a series of 1.5km² wide parallel counting strips. White rhino did not run far ahead of the line, and invariably broke through it indicating that the method should count them accurately (P.M Brooks pers.obs.). Errors caused by animals moving between lines during the count should have on average cancelled each other out.

#15 Reilly Brian, K., Richard II. Emslie & Keryn Adcock (in prep) Power analyses of replicated helicopter counts in an African Game Reserve.

#16 Bothma J du P., M.J.S. Peel, S. Pettit & D. Grossman (1990). Evaluating the accuracy of some commonly used game counting methods. *S.Afr. J. Wildl. Res.* 20(1):26-32.

Eltringham S.K. (1979) The ecology and conservation of large African mammals. *Macmillan Press*, London.

Graham A. & R. Bell (1968) Factors influencing the countability of animals. *E.Afr. Agric. For. J.* 34:38-43

Pennycuik C.J. & D. Western (1972) An investigation of some sources of bias in aerial transect sampling of large mammal populations. *E.Afr. Wildl. J.* 10:175-191

Short J. & P. Bayliss (1985) Bias in aerial survey of kangaroo density. *J. Appl. Ecol.* 22:415-422

#17 Knott A.P. (1983a) A preliminary assessment of ungulate censusing techniques in Northern Hluhluwe Game Reserve with particular reference to impala, nyala and warthog numbers. *Unpubl. NPB report 21pp*

Knott A.P. (1983b) A record of the August 1983 Helicopter Census of the Hluhluwe and Umfolozi Game Reserves, including removal recommendations for the remainder of the 1983/84 removal year. *Unpubl. NPB report 17pp*

#18 Keryn Adcock (pers comm 1995). Chairman of the South African Statistical Association/Conservation Scientists Working Group on Game Population Estimation. Consultant ecologist specialising in population estimation and rhino related research and monitoring. Worked as professional ecologist for both North West Environmental Conservation (NWEK, previously Bop Parks - management authority for both Pilanesberg N.P. and Madikwe G.R.); and for the Natal Parks Board in Hluhluwe-Umfolozi Park. She organised and analysed the 1991 Hluhluwe-Umfolozi line transect programme data (Fourier series model using TRANSECT program) and produced the 1991 official estimate of 1,988 (rounded to 2,000). See also #21.

#19 K. Landman & Kay Hiscocks (pers comm. 1995). Mr Karel Landman is the owner and manager of the area of Pongolapoort that was surveyed. He is also the Chairman of the Natal Game Ranchers Association. The helicopter counts were undertaken by the Agricultural Research Council's Game Production Unit as part of a population estimation techniques study.

#20 Maddock Ant (pers. comm. 1995). As the Regional Ecologist for Hluhluwe-Umfolozi Park he organised and analysed data from the 1994 Hluhluwe-Umfolozi line transect programme using a Fourier series model and the TRANSECT program. The NPB is holding an internal workshop on

population estimation in March, and later in the year Dr. Burnham will be visiting from the USA to give a course on distance sampling methods.

#21 Adcock Keryn (in prep 1995) Results of a comparative aerial line transect study in Madikwe Game Reserve. *Internal NWEK report.*

Adcock Keryn (in prep 1995) Proposals on population estimation procedures for Madikwe Game Reserve. *Internal NWEK report.*

Fieldwork for the Madikwe aerial line transect experiment was undertaken in late 1994. Two helicopters (Bell Jet-Ranger and Hughes 500) and two fixed-wing aircraft (Kruger N.P.'s Partenavia and a Cessna) were used. The Hughes 500 and pilot were the same as used in the 1994 Hluhluwe-Umfolozi Park. Madikwe has recently been restocked with many species, and so the actual numbers of some species are known with a reasonable degree of accuracy, providing a good test of the technique, and different aerial platforms. Unfortunately the white rhino population in Madikwe is still small (≈ 54), and thus insufficient sightings of the white rhino in the Park were obtained to produce a reasonable population estimate, although the data did give an idea of distribution of sightings with distance from the helicopter flight path.

#22 Emslie Richard II. & Tony Bowland (pers comm 1995).

#23 Snyman Heidi (pers comm 1995).

#24 Buckland S.T., D.R. Anderson, K.P. Burnham & J.L. Laake. (1993) Distance sampling: estimating abundance of biological populations. *Chapman and Hall*, New York pp446

Interested readers should also consult.. Burnham K.P., D.R. Anderson, & J.L. Laake. (1980) Estimation of density from line transect sampling of biological populations. *Wildl. Monogr.* 72: 1-202

Strictly speaking, the density estimates produced using the line transect method uses the mathematical function fitted to the sighting histogram to produce a best estimate of the density of groups on the line (where we have assumed we did not miss any animals). This figure also represents our best estimate of the density of groups in the Park. In technical language this = the value of the probability density function of perpendicular distances at zero distance (i.e. on the line). However the key concept discussed above, that the distance data collected is used to estimate the fraction of the population that was missed, still holds.

#25: Substantial effort may be required in order to obtain large enough sample sizes (at least 60 groups and preferably over 120 groups) to produce reasonable line transect estimates. Sample sizes in the Hluhluwe-Umfolozi programme were far in excess of minimum requirements.

If not applied properly as a result of insufficient training of observers, or failure of observers to carry out instructions, poor "spiked" sighting graphs may be produced which are difficult to model leading to imprecise density estimation²⁴. Such problems invariably are due either to poor survey design or execution²⁴.

In Hluhluwe-Umfolozi great care has gone into survey design which includes cutting lines to minimise the chance of disturbing, and hence missing animals near, or on the line. However, although narrow, the "cut" lines may sometimes be used as pathways by the animals introducing error into the estimation.

If observers have followed instructions then the sighting graph should exhibit a "shoulder" rather than be markedly "spiked"²⁴. The sighting curves obtained in both Hluhluwe and Umfolozi during the 1994 line transect programme²⁰ showed slight/moderate but certainly not extreme spikes.

If for some reason an observer has not followed instructions and routinely underestimated distances to the animals seen, this will act to bias estimates upwards.

In an attempt to reduce the likelihood of such problems Hluhluwe-Umfolozi observers are trained before doing the transects, and each range finder/observer combination is individually calibrated.

In 1994 the majority of routes walked in the Hluhluwe-Umfolozi programme were undertaken by research staff, game rangers and experienced students²⁰. Accurate Suntu compasses were also used to measure angles as accurately as possible.

Data from any potentially suspect observers were also scrutinised for any signs that they may have been improperly collected. In one instance in 1994, a problem was discovered and data from one observer's first two walks were discarded, and the particular observer re-trained to correct the problem²⁰.

Herding species can cause problems with line transect estimation as large groups are more easily detected further from the line than single animals. This can lead to an overestimate in average group size which in turn will bias estimates upwards²⁰. However this problem most seriously affects herding species such as impala, wildebeest and buffalo rather than white rhino. At the time of writing the NPB has not evaluated whether mean white rhino group size varied with distance in 1994, although the mean group size recorded on the line transect programme was similar to that recorded during aerial counts and on a recent ground-based age and sex survey, suggesting it probably didn't²⁰. This issue was however investigated in 1991, and found only to be a problem with big herding species such as Buffalo¹⁸.

Despite training, some observers tend to round numbers off to the nearest 5 or 10 animals, but given the usual small white rhino group sizes this will not pose a problem.

If many transects are walked with a tailwind, the method can bias estimates downwards, as animals on or near the line may smell the observers and move off before being detected. The Park's prevailing wind was taken into consideration when originally setting transect direction (P.M. Brooks pers. comm. 1995). This should reduce (but not eliminate) the chance of wind biasing the results during counts.

The success of the programme depends on the extent to which observers followed instructions. On an exercise of this magnitude problems probably occur; but these are most likely to be of a lesser magnitude than those affecting population estimation based on single aerial counts.

#26 Using an "observation post" ground count technique staff at Itala Game Reserve, South Africa came up with a minimum number of white rhino of 97 (Tony Bowland pers. comm.). By way of contrast four replicated total area fixed wing counts in the reserve only counted from between 42 to 50 white rhino (Tony Bowland pers. comm.). Even though the topography makes fixed-wing flying conditions in Itala less favourable than in Hluhluwe-Umfolozi, this indicates a substantial undercounting bias.

For a helicopter to count all but 10% of the white rhino in Itala, it would mean it would have to count at least twice as many animals as the fixed-wing aircraft, and even allowing for the terrain this seems highly unlikely. Interestingly, this study suggests that the fixed-wing only counted about 40% of the white rhinos, which is very similar the 42% estimated missed by the fixed-wing in Umfolozi using data in Knott & Brooks (1986)¹⁴.

#27 In Kruger National Park, annual total area aerial surveys using a six-seater Partenavia fixed-wing aircraft have recorded an average annual growth rate of the white rhino population since 1980 of 8.4%/annum (National Parks Board data - Danie Pienaar pers. comm.). By applying this growth rate to the known introductions, approximate annual population estimates were modelled for the Park since the white rhino population was reintroduced.

A range of "undercount" levels were then applied to the estimated annual population sizes to simulate annual count totals. In order to estimate the most likely proportion of white rhino being missed during the annual Kruger aerial counts, modelling varied the "undercounting" bias till the discrepancies (sums of squares) between the estimated and actual number counted during the Kruger annual aerial surveys was minimised. In this way the AIRSG obtained rough estimates of probable undercounting bias.

Depending on how successful the initial introductions were, the model indicated that the annual Kruger aerial survey was probably counting between 67% and 75% of the white rhino.

The Kruger Partenavia aircraft took part in the Madikwe Game Reserve experiment²¹; and for bigger more visible species like white rhino it appeared to count about 85% of the white rhino groups counted by the Hughes 500/Bell Jet Ranger helicopters^{18,21}. This suggests that a helicopter probably would possibly miss between 11% and 21% of the white rhino in Kruger Park. However, as Kruger is flatter and has better visibility than Hluhluwe-Umfolozi; this crude modelling suggests that a helicopter would most probably miss 25% + white rhino in the denser Hluhluwe-Umfolozi Park.

#28 Approximate confidence limits based on extrapolating the 90% confidence interval of $\pm 17.46\%$ around the pure line transect estimate to the estimate of 2,077 for the whole Park).

#29 Mr Derek Potter, Natal Parks Board Deputy Director East.

#30 Dr. Berty van Hensbergen, Dept. of Nature Conservation, Stellenbosch University.