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A LEGAL TRADE IN RHINO HORN: HOBSON'S CHOICE

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Executive Summary

South Africa has some 20,000 rhino (18,000 white and 2,000 black) which, theoretically, could sustain an illegal hunting offtake of about 6% of the population annually (1,200 animals). If the trend in numbers hunted illegally continues at its present rate this threshold will be exceeded in 2013. There are two schools of thought as to the best strategy to confront this undesirable state of affairs. The first, ***More of the Same***, sees an increase in law enforcement and security as being the best approach. The second strategy, ***Radical Change***, espoused mainly by the primary stakeholders in rhino conservation (SANParks, KWZN Parks and private landholders with a large investment in rhino) sees greater promise in the inception of a legal trade in rhino horn, believing that this will reduce the illegal hunting challenge and, most importantly, realise the funds needed to contain that challenge.

This paper evaluates the two contrasting approaches using a population simulation model. A framework is set up for the ***More of the Same*** scenario which replicates the present illegal hunting regime and tests various levels of protection. This framework is then used to find the degree of reduction in the illegal hunting challenge which the legal trade in rhino horn (the ***Radical Change*** scenario) would be required to achieve to make the illegal hunting sustainable under a range of conditions.

More of the Same

The options available to the ***More of the Same*** scenario to counter the illegal hunting are assessed and almost all of them are rejected because they have been tested over the past 30 years and have failed. The only feasible option is *in situ* protection for the rhino but, for this option to be effective, the costs are prohibitive. It is estimated that the annual cost needed to secure the survival of the South African rhino population (black and white) at its present level is about **US$400million (R3.3 billion)**. As it increases towards carrying capacity the figure will rise to more than **US$600 million (R4.5 billion)**.

Such a level of annual recurrent expenditure is unjustifiable in a country where social considerations and poverty alleviation are paramount. **The entire venture is economically unsound**. Far from creating an enabling environment where the numbers of rhino will increase through range expansion, the ongoing investment results in a static, unproductive population which will level off somewhere above the ecological carrying capacity of its present range. The option of selling rhino to private landholders in order to keep the KNP population below ecological carrying capacity is now effectively closed because rhino are being seen as a liability by the potential recipients. **It is a 'lose-lose' scenario**.

Radical Change

This section begins by assessing the present financial value of South Africa's investment in rhino. The capital value of all the horn on 20,000 rhinos is about **US$780 million**. This figure is about double the required annual expenditure to protect the present population (US$ 400 million). It reinforces the economic absurdity of investing solely in protection – to spend a million dollars annually to protect an asset worth two million dollars is an exorbitant insurance policy.

The present stock of rhino horn in State custody and private hands can be crudely estimated at about 16 tonnes ... worth about **US$160 million** at current black market prices. This would not be able to meet the exorbitant protection costs of the 'more-of-the-same' strategy if it were liquidated in the first year.

A population of 20,000 rhinos can be expected to produce horn worth about **US$10 million** from natural mortality alone. However, this amount (about US$500/animal) would come nowhere close to meeting the protection costs for rhinos under the present level of illegal hunting challenge.

The annual horn production from a small population of white rhino managed under a dehorning regime averages slightly less than 1kg per rhino per year. Thus every animal in such a population is capable of earning a sustainable annual income of about **US$10,000**. A hundred animals would generate **US$1 million** annually. **The land use value of rhino managed under dehorning is at least 100 times greater than that of domestic livestock**.

Method of selling rhino horn

It is recommended that sale of rhino horn be done in a manner similar to that which has been successfully used by de Beers' Central Selling Organisation for over a century to run the international trade in diamonds. The new entity might be named the **Rhino Horn Selling Organisation (RHSO)** .

The **RHSO** would have two aims –

1. To maximise the returns from sale of horn within the constraints imposed by the second aim;
2. To reduce the demand for horn from illegal hunting.

How would the illegal demand be reduced ? Very simply by stealing the customers away from the illegal traders. **This is a critical insight**. At the moment, all of the horn in the international trade is illegal and all of the customers for that horn rely on the black marketeers. Any horn purchased legally from the RHSO has the unique characteristic that it has not caused the illegal killing of a rhino. Logically, the more customers there are that obtain their horn from the RHSO, the fewer are the numbers of rhino being killed illegally for any given level of demand. The RHSO has at its disposal a stock of horn which is probably many times larger than any illegal stockpile. Its tools are the volumes of horn it can release onto the market and the prices it can set at each sale.

The simulation model takes into account two effects which operate at any given level of protection. The first is the initial rate of rhino loss at the given level and the second is the rate of escalation of the loss with time, i.e. for any given level of protection the loss does not remain constant – it increases at that level. This is well demonstrated by statistics presented by Emslie (2010) for the overall rate of loss of rhino where the law enforcement level has remained fairly constant with time. The rate of loss increased from 1 rhino every 4 days in 2008 to 1 rhino every 3 days in 2009 and to 1 rhino every day in 2010. The rate of loss escalates at higher rates when the law enforcement effort is low than when it is high.

For the legal trade to work it must 'hijack' customers away from the black marketeers. Because the rate of illegal hunting escalates at any given level of law enforcement, so too must the rate at which the end-users of rhino horn convert to using legal horn. It requires very minor alterations to that rate of escalation in order to make the losses sustainable.

The lowest expectation of the legal trade is that it should hijack sufficient customers away from the black marketeers to ensure survival of the rhino population. At present levels of law enforcement, this requires the percentages by which the numbers illegally hunted are reduced to escalate from 3.6% to 36.2% over the first ten years after the inception of a legal trade. If the requirement is not merely survival of the rhino population but that it should not fall below ecological carrying capacity (about 10,000 animals for the KNP population), these percentages need to increase from 6% to 60% over the first 10 years.

After the legal trade has been in effect for several years, there is a positive feedback effect where the legal trade causes an increasing reduction in the numbers being hunted illegally each year and, after a certain point on the trajectory, the combination of fewer numbers being hunted illegally with a higher proportion of those numbers being hijacked results in the collapse of the illegal hunting.

Under the assumptions in the population simulation model for the parameters which will operate when a legal trade is in place, the rhino population increases briefly near the start while the illegal hunting is still sustainable, then it declines as the illegal hunting escalates and, finally, it recovers as the legal trade starts to 'bite'. At the present law enforcement level the decline takes place fairly soon after the start and it then bottoms out in the year 2026 before the population climbs back up to an asymptote of some 17,000 rhino (for the KNP population). What may turn out to be an important point in the future management of rhino is that, **if the legal trade can achieve this 'turn around' at the present level of law enforcement, the recovery is faster than it would be if more money were being spent on law enforcement and the initial rates of population decline were lower**.

A key insight from this modelling is that if the legal trade achieves the requirements for the present level of law enforcement then **there is no need to increase expenditure on law enforcement**.

Of course, if the legal trade were successful at achieving the reduction in illegal hunting required for the population to remain above ecological carrying capacity, the situation of a subsequent increase to 17,000 rhinos in KNP is not what would happen. Those rhino populations which were at ecological carrying capacity would immediately be managed to avoid a further increase in their numbers (du Toit 2006) and rhino would be sold and translocated to new properties. It could also be anticipated that the live sales price for rhino would increase since the inception of a legal trade would provide a huge incentive for conversion of land to rhino 'farming'. This would result in an increase in the range available to rhino, the maintenance of the maximum growth rate for rhino, an increase in the national population of rhino and a generally positive scenario of wealth being generated for all primary stakeholders with rhino on their land.

Costs of decisions

Several scenarios have been simulated. (**Table A3.3**, p30 and **Fig.A3.7**, p31). For all of these scenarios, I have assumed that law enforcement effort remains at its present level.

No legal trade

(1) If it were decided not to take the 'risk' of engaging in a legal trade in rhino horn, according to the assumptions underpinning the simulation model the entire rhino population would be lost over the period 2012-24. This loss, which takes into account the annual increments to the population through breeding and the annual losses from illegal hunting is **US$2.9 billion** (Rands 22 billion).

In any other sphere of commerce, were a bureaucracy to lose twenty-two billion rands, it would result in a national outcry, parliamentary investigations and court charges. Somehow conservation agencies appear exempt from this.

Legal trade beginning in 2013

(2) Under the framework simulated by the population model, the legal trade reduces the number of rhinos killed illegally from 2013-2024 and ensures that the rhino population not only survives but also survives in substantial numbers, i.e. above 16,700 animals when the assumed ecological carrying capacity for Kruger National Park is extrapolated to the national level. The financial saving to the nation from this is some **US$1.6 billion** (R12 billion). The figure does not include the income which would have been generated from the sale of rhino horn from 2013-2024.

Legal trade beginning in 2016

(3) Delaying the submission of a proposal for a legal trade in rhino horn from 2013 to 2016 results in an additional cost of **US$996 million** (R7.5 billion) arising from the continuing loss of rhino between 2013 and 2016. Should DEAT elect not to submit a proposal to the next CITES COP (March 2013) it should be answerable to the nation at large for this huge loss.

Another factor should influence the decision whether or not to submit a proposal for legal trade to the coming CITES COP. At present the annual loss of rhino is sustainable but if it continues to escalate at current rates it will become unsustainable within two years (Emslie 2010). If South Africa approaches the CITES Parties with the argument that, despite a massive commitment to law enforcement, losses are escalating and it needs the legal trade to ensure that the loss does not become unsustainable, there is an excellent chance that it will be successful. If, however, it waits until 2016 in the vain hope that it will get on top of the situation and ends up losing the numbers of rhinos predicted in this study, the CITES Parties are likely to view South Africa very differently. It will be seen as a Party which, despite its past conservation record, has now allowed illegal hunting to get out of control and cannot be trusted to implement a legal trade effectively.

FINANCIAL IMPLICATIONS OF A LEGAL TRADE IN RHINO HORN

The results from the simulation modelling have been used to examine how a legal trade might perform (**Appendix 4** page 32). The analysis applies to the Kruger National Park rhino population which is assumed to be some 12,000 animals in 2012 (the figures can be scaled up to the national level by using a factor of 1.67). The scenario examined is that where the legal trade hijacks sufficient end-users from the black marketeers to prevent the population falling below 10,000 animals (ecological carrying capacity).

Population numbers

The full effects of a legal trade in reducing the numbers illegally hunted are not felt for several years. The population increases for the first 5 years reaching a peak of 14,300 animals in 2018 and then declines to its lowest value of 10,100 animals in 2027. It then begins to recover reaching an asymptote of some 17,000 animals in 2044.

Illegal hunting

The numbers hunted illegally reach a peak of 1,886 in 2025. Thereafter, the illegal trade is effectively finished and illegal hunting falls to 10 animals per year after 2029. The annual financial loss reaches a peak of **US$150 million in 2025**. These losses do not actually appear in any books of account. The amount of horn which would be required to be sold annually to offset this loss rises to 15 tonnes in 2025 (effectively the entire stock of horn in South Africa). Fortunately, there is no requirement to ensure that the amount from annual horn sales causes the ledger balance to remain at all times 'in the black'.

Sources of horn

Horn is available from natural mortality, from dehorning operations and from existing stocks. Horn from confiscations is automatically incorporated into existing stocks. The total amount of horn appearing on sale in any given year averages about **4.5 tonnes per year**.

Horn stocks

The starting stock of horn in 2012 has been obtained by assuming the total stock of horn in South Africa is 16 tonnes and, of this, about 9.6 tonnes 'belongs' to KNP. The strategy for management of this stockpile would rest with the RHSO and, by small variations in the percentage appearing on sales, the overall stock can be made to increase or decrease in the long term. It might be sound strategy to always maintain a strong 'capital base'.

Annual income from sales

The sale price has been fixed from 2013-2044 and results in an average annual income of about **US$45 million**. In practice, the RHSO would vary the price from sale to sale depending on the immediate objectives. The cumulative gross income earned from sale of horn over the period 2013-2044 is **US$1.4 billion**. The average income per rhino per year in this scenario is around **US$3,100**. It can be raised to US$4,000 by increasing the dehorning percentage and the percentage of stocks placed on sale.

Ledger balance

This is the reconciliation of the full value of rhino losses with the gross income earned from horn sales over the period 2012-2044, i.e. what would be shown by any ordinary bank statement. I have pointed out that, under present accounting systems, the losses of rhino to illegal hunting do not 'appear in the books'. When they are made to appear in the books, it transpires under the given scenario that after an initial positive balance up to 2020 the ledger shows a massive deficit from 2021-2039. This is the period where the losses of the past are being paid for. The mortgage is acquitted in 2040 and from then onwards the 'true account' is 'in the black', ending with a credit of US$570 million in the year 2050.

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All of the income referred to above is gross income. It does not take into account the costs of protecting the rhino. An average income of US$3,100 per rhino (see above) would more or less meet the present allocation for rhino protection in Kruger National Park.

A key variable in this analysis is the proportion of the total rhino population which is subject to a dehorning regime. The horn generated from dehorning is by far the largest component of the total horn presented for sale. If all rhino were subject to dehorning, the gross annual income per rhino rises to over US$8,000 and would not only meet all protection costs but would also leave SANParks with a substantial profit. To some extent this is academic: SANParks is unlikely to manage its white rhino for the maximum production of rhino horn. However, it is a measure of what a private landholder might expect from a 100% dehorning regime.

If the legal trade in rhino horn works and reduces illegal hunting to a very low level (as predicted by the scenarios presented in this study), the actual costs of rhino protection may be significantly reduced – in which case the returns from sale of horn become pure profit.

A final consideration is the price which rhino horn will fetch on the legal market. The analysis has used a fixed price of US$10,000/kg throughout but manipulations of the price by the RHSO may result in considerably higher figures. At present, the black market price in South Africa is some US$10,000/kg but the amount which the end-user of rhino horn is paying may be between 4-6 times this amount. If the legal trade is successful in reducing the length of the supply chain which exists in the black market and horn can be delivered to the consumer more directly it is possible that a greater profit can be made.

SUMMING UP

Unlike the '**more-of-the-same**' scenario, the '**radical change**' scenario offers space for experimentation with very little risk involved. If the legal trade is not achieving its aim, it is easy to stop it. The 'more-of-the-same' scenario has no fall-back position – it has nailed its colours to the mast and is committed to doing the right thing all the way to the extinction of rhino.

The pessimist's position is that venturing into a legal trade carries the risk of things getting even worse than they are now. The illegal hunting from the South African rhino population has reached the point where, if it continues at its present rate, it will be unsustainable within two years and the population will be extinct by 2024. It is difficult to conceive of a more grave situation than this.

The optimist would look at the potential win-win situation. The resource (rhino horn) is incredibly valuable. There is a substantial demand for the resource. Exploited shrewdly, this demand could provide the wealth that resulted in increasing investment in rhino, transformed land use in southern Africa and achieved an explosion in rhino population numbers.

Evaluating the two scenarios, we are left with Hobson's Choice.

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Acronyms

CC	– Carrying capacity
CITES	– Convention on International Trade in Endangered Species
COP	– Conference of the Parties [to CITES]
KNP	– Kruger National Park
KWZN Parks	– Kwazulu Natal Parks
RHSO	– Rhino Horn Selling Organisation
SA	– South Africa
SANParks	– South African National Parks

Acknowledgement

I was enjoying a nightcap on 22 September 2011 at Chilo Lodge on the Save River in the south-east lowveld of Zimbabwe with a local veterinarian Dr Charles Waghorn. The occasion was Professor Marshall Murphree's 60th wedding anniversary and Charles is married to one of Marshall's daughters Dr. Debra Murphree – who also happens to be my doctor. I told Charles how nettled I was at an e-mail communication I had received a few days earlier from the Department of the Environment in the United Kingdom in response to an e-mail I had sent them saying that I had just completed a 6 week tour of South Africa and found an overwhelming consensus of opinion that a legal trade in rhino horn was needed to combat the illegal hunting of rhino. The response was that it was far to risky to contemplate such a trade and that the UK, at the request of CITES, would be spearheading an initiative to reduce the illegal hunting of rhino in South Africa using all the "more-of-the-same" methods referred to in this study.

Charles listened patiently to my diatribe and then suggested that South Africa should ask the UK to insure its rhino if it were to follow their approach towards solving the illegal hunting problem. Before I fell asleep that night, I resolved to use a simulation model to evaluate the costs of the "more-of-the-same" approach .... which led to this study. I thank Charles – his suggestion was the stimulus for this paper and no other persons have been involved.

A LEGAL TRADE IN RHINO HORN: HOBSON'S CHOICE [1]

R.B. Martin [2]

The recent escalation of illegal hunting of rhino in South Africa has attracted world wide concern and publicity. The number of rhino illegally hunted since 2005 has been more or less doubling every year.[3] South Africa has some 20,000 rhino (18,000 white and 2,000 black) which, theoretically, could sustain an illegal hunting offtake of about 6% of the population annually (1,200 animals). If the trend in numbers hunted illegally continues at its present rate this threshold will be exceeded in 2013.

Two schools of thought are emerging as to the most promising strategy to confront this undesirable state of affairs. The first sees an increase in law enforcement and security as being the best approach. Recently, the United Kingdom was tasked by the Standing Committee of CITES to spearhead an initiative aimed at reducing the illegal hunting and it proposes to do this largely through intensified efforts in trade controls. The second school of thought espoused mainly by the primary stakeholders in rhino conservation (SANParks, KWZN Parks and private landholders with a large investment in rhino) sees greater promise in the inception of a legal trade in rhino horn, believing that this will reduce the illegal hunting challenge and, most importantly, realise the funds needed to contain that challenge.

This paper evaluates the two contrasting approaches using a simple simulation model. I am not testing hypotheses – rather I am evaluating scenarios. In both cases I am stating the implicit assumptions. To give a more immediate flavour to the analysis I am characterising the players as **A** and **B**. **A** represents the group (led by the United Kingdom) who are pinning their hopes on greater enforcement, i.e. "**more-of-the same**"– a phrase with which UK citizens are very familiar when considering government performance. **B** represents the group who wants to see major changes to current practices (led by the Young Turks[4] in South Africa) and is willing to experiment with **a legal trade in rhino horn**.

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1. A **Hobson's choice** is a free choice in which only one option is offered. As a person may refuse to take that option, the choice is therefore between taking the option or not – i.e. "take it or leave it". The phrase originates with Thomas Hobson (1544–1631), a livery stable owner in Cambridge, England. To rotate the use of his horses, he offered customers the choice of either taking the horse in the stall nearest the door or taking none at all. [*Wikipedia*]

2. Rowan Martin worked for the Zimbabwe wildlife department from 1972-1995 and has been practising as an independent wildlife consultant since 1995.

3. There are several ways of analysing the data. Depending on the method chosen, the rate of escalation varies between 75% and 150% per annum.

4. The term **Young Turks** refers to the members of Ottoman society in the 1900s who were progressive, modernist and opposed to the status quo. The movement built a rich tradition of dissent that shaped the intellectual, political and artistic life of the late Ottoman period generally transcendent to the decline and dissolution periods. Many Young Turks were not only active in the political arena, but were also artists, administrators, or scientists. [*Wikipedia*]

Both **A** and **B** have personalities rooted in their deep-seated convictions about the "right way" of conserving. Both have the same **goal**: the ultimate survival of rhino and an increase in their numbers. Both have fairly pure motives. I say 'fairly pure' because **A** also has a political motive – success in reducing illegal hunting will redound to their political status. **B** has a financial motive (filthy lucre) – increasing the numbers of rhino will bring this group wealth.

'More-of the-same'

The options available to **A** are to –

(1) Increase protection for rhinos *in situ*;

(2) Increase penalties for illegal hunting and being 'caught in possession';

(3) Place a major effort on detection of illegal horn along the full pathway from the source of horn to the end-consumer;

(4) Root out corruption both at the national and international level which facilitates the illegal trade in rhino horn; and

(5) Promote awareness campaigns aimed at educating the consumers of rhino horn that its medicinal properties are ficticious and their demand for the product is leading to the demise of the species.[5]

We will examine these components of the strategy in reverse order – it is easier to deal with the most obviously unworkable approaches first.

(5) Awareness campaigns

It is irrelevant whether rhino horn is a desirable medicinal product. The demand for the commodity is real and has persisted for a thousand years in the East. This is as much a cultural issue as it is a medical issue and it is somewhat arrogant for the West to assume it has the imprimatur on the matter. Such 'awareness campaigns' do not work.

(4) Corruption

This is a societal issue extending well beyond issues to do with illegal trade in rhino horn.[6] There are no simple answers to eliminating corruption but a 'watertight' legal trade in rhino horn may offer better prospects than sermons from the pulpit.

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5. To this might be added awareness campaigns targeted at illegal hunters to convince them that their behaviour is repugnant and socially unacceptable.

6. Ultimately, corruption was responsible for the demise of black rhino in Zimbabwe. It began with the removal of all competent anti-poaching staff from the areas where there were rhino – directed from the head office of the wildlife department. The field staff remaining in the areas either facilitated the hunting of rhino by outsiders or did it themselves – under direction from higher authority. The horns were delivered to the embassies of certain Asian countries in Harare. In 1996, the United States intercepted a payment of US$7 million from North Korea to a member of parliament in Zimbabwe who was intimately involved with the senior staff of the Zimbabwe wildlife department. There were no satisfactory investigations of the matter.

(3) **Detection of illegal horn from the source of horn to the end-consumer**

This strategy makes the false assumption that there would be a deterrent effect in catching 'middle-men' involved in the illegal trade. The topic is dealt with more fully below.

(2) **Increase penalties for illegal hunting and being 'caught in possession'**

One of the wrong assumptions that underpinned the law enforcement effort during the time that Zimbabwe lost most of its black rhino (1983-1994) was that a deterrent value existed in jailing (or killing) illegal hunters. This was not the case. The number of illegal hunters was too large and the incentive for illegal hunting was too high. The same is true for illegal traders. Today, the price of rhino horn is so high (US$10,000 per kg) that, for poor people, the gains from illegal hunting outweigh the risks – even the possibility of death. One might as well talk about deterrents for suicide bombers.

(1) **Increase protection for rhinos *in situ***

Another wrong assumption that underpinned the law enforcement effort during the time that Zimbabwe lost its rhino was the notion that there were a finite number of illegal hunters and if these could apprehended (or killed) it would remove the scourge. This was wrong. There was an infinite number of potential illegal hunters and when one gang was removed another was ready to take its place.

The law enforcement method was largely reactive. On hearing shots, an incident was investigated. It usually led to a rhino carcase which resulted in a follow-up operation and a gang of illegal hunters was either killed or arrested. Staff complimented themselves on a job well done. The problem was that there were more such incidents than there were rhino. Every clash with illegal hunters came after they had killed a rhino and Zimbabwe ran out of rhino before it ran out of illegal hunters.

For the law enforcement to have been successful, illegal hunters would have had to be detected before they had been able to kill a rhino. In an area such as the Zambezi Valley (10,000km^2) this would have required an intense law enforcement effort (more than one man to10km^2) and this was beyond the financial resources of the wildlife agency. **One overarching lesson to be learnt out of the Zimbabwe experience is that emphasis on traditional law enforcement is unlikely to work – especially if more insidious influences are present**.

This is nevertheless the only component of the 'more-of-the-same' strategy which can be quantified and assessed. At present Kruger National Park has some 12,000 rhinos (11,500 white and more than 500 black). I will focus on this population because (a) it contains more than half of the rhinos in South Africa; (b) the results from its analysis can reasonably be extrapolated to the full population in South Africa and, (c), it provides the initial conditions for examining what a legal trade in rhino horn would have to achieve to alter the present dynamics of the situation. These initial conditions are examined in **Appendix 1** (page 16).

The minimum law enforcement effort needed to provide adequate protection is about one 'stick' to three rhinos, which implies some **US$20,000** per rhino.[7] The present expenditure is less than US$4,000 per rhino. Applying this figure to the total rhino population of South Africa, **an annual recurrent expenditure of US$400million (R3.3 billion) is required in 2012**.

For Kruger National Park, this is far from the end of the story. The present population of white rhino is close to ecological carrying capacity and, under normal circumstances, white rhino would be sold to private landholders to alleviate the pressure. **But now there are few buyers** – in the present climate of uncertainty, rhino are being seen as a liability.

Assuming adequate protection, the Kruger population would probably level off at about 17,000 white rhino through homeostatic mechanisms.[8] Ignoring inflation and including the black rhino, this would raise the total annual cost for protection of the Kruger rhino to some US$380 million. Assuming that similar processes are taking place outside Kruger, the total protection cost for the South African rhino population (black and white) will rise to around **US$635 million (R4.8 billion)** as populations reach carrying capacity.

Pause to consider this. In a country where social considerations and poverty alleviation are paramount, it is unlikely that the parliament would entertain such expenditure. Especially when there are almost no prospective returns from the investment. The economic contribution of rhino to tourism in general and wildlife in particular is relatively small (Spencely & Barnes 2005). Rhino could be hunted outside the national parks but with the present trophy fee of about US$40,000 for a white rhino (which would probably decrease with an abundance of rhino) and an overhead cost of U$20,000 per year to keep the animal alive, the return is marginal.

An overall annual recurrent expenditure of US$635 million is unjustifiable – even if it could be leveraged from an outside donor such as the UK. **The entire venture is economically unsound**. Far from creating an enabling environment where the numbers of rhino will increase, the ongoing investment results in a static, unproductive population. **It is a 'lose-lose' scenario** (**Fig.1**, p5).

On the first page of this paper, we assigned personalities to the players in the two scenarios being evaluated. **A** may be a bit of a bully attempting to coerce **B** into following its prescription for the 'right way' to save the rhino. **B** is slightly overawed by **A** but is far from certain that **A** has all the answers. **B** agrees provisionally to go along with **A**'s approach but, in order to safeguard its present investment, it asks **A** to insure its rhino – that way, if **A** is wrong and **B**'s rhino disappear, **B** will at least have the consolation of some financial return. Assuming **A is** wrong and assuming an insurance value of US$80,000 per rhino [9], the insurance bill that **A** would have to foot for the loss of the entire rhino population over the period 2012-2024 would be **US$2.9 billion dollars** (**Table A3.3**, p30). This might cause **A** to reconsider its strategy.

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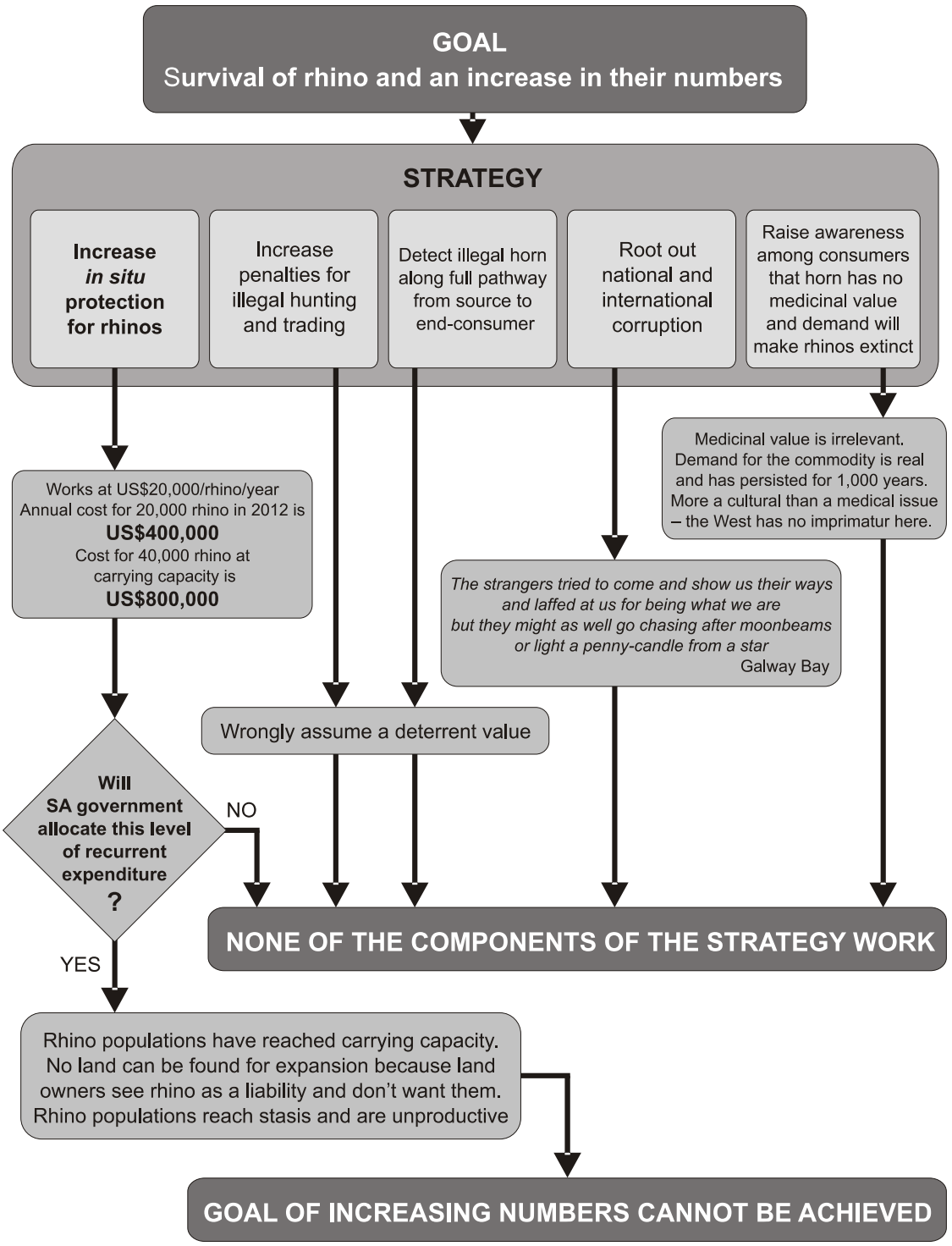
7. A 'stick' consists of 2 game guards. Assuming three shifts of 8 hours, 6 game guards are required for every 3 rhino. At an annual salary of US$10,000/game guard, the cost per rhino is US$20,000.

8. Age at first conception would increase, intercalving interval would lengthen and natural mortality would increase. See **Appendix 1** for the values used.

9. The present live sale price for rhino is about US$40,000. To this must be added the value of about 4kg of horn worth US$10,000/kg.

Figure 1: **'More-of-the-same' strategy – outcomes**



A 'LOSE - LOSE' SITUATION

This sets the stage for consideration of the alternative of '**radical change**' which might be brought about by a legal trade in rhino horn.

'Radical Change'
or
The inception of a legal trade in rhino horn

To begin examining the implications of a legal trade in rhino horn, we need some ball-park figures for the financial value of the horn on the present rhino population in South Africa.

Capital value

The average weight of horn on a living white rhino is about 3.9kg. Thus, at a price of US$10,000/kg, the capital value of all the horn on 20,000 rhinos is about **US$780 million**. This figure is about double the required annual expenditure to protect the present population (US$ 400 million). It reinforces the economic absurdity of investing solely in protection – to spend a million dollars annually to protect an asset worth two million dollars is an exorbitant insurance policy.

The present stock of rhino horn in State custody and in private hands can be crudely estimated at about 16 tonnes ... worth about **US$160 million**. This would not be able to meet the exorbitant protection costs of the 'more-of-the-same' strategy if it were liquidated in the first year.

Value of horn recovered from natural mortality

The average weight of horn which might be expected to be recovered annually from natural deaths in a white rhino population is about 0.05kg/rhino. Thus, we could expect a population of 20,000 rhinos to produce horn worth about US$10 million from natural mortality alone. However, this amount (about US$500/animal) would come nowhere close to meeting the protection costs for rhinos under the present level of illegal hunting challenge.

Value of horn recovered from dehorning

The annual horn production from a small population of white rhino managed under a dehorning regime averages about 1kg per rhino per year. Thus every animal in such a population is capable of earning a sustainable annual income of about US$10,000. A hundred animals would generate US$ 1 million annually. If these rhino were to survive entirely off natural vegetation, at an average rainfall of 700mm the stocking level would be about 1 rhino/km^2. This translates into a gross land use value of US$100/ha: under the same rainfall conditions, cattle production would earn slightly more than US$1/ha.[10] Herein endeth the first lesson: **the land use value of rhino managed under dehorning is at least 100 times greater than that of domestic livestock**.

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10. With a higher rainfall and supplementary feeding, the stocking level could increase by a factor of 10. One rhino ranch on highveld grassland in the North-West province manages its rhino at 1animal/10ha.

Before going further, it would be as well to outline the *modus operandi* which might be adopted for conducting a legal trade in rhino horn. I am recommending that it be done in a manner similar to that which has been successfully operated by de Beers' Central Selling Organisation for over a century in running the international trade in diamonds (**Appendix 2**, p21). The new entity might be named the **Rhino Horn Selling Organisation (RHSO)** .

Strategy of the Rhino Horn Selling Organisation

The **RHSO** would have two aims –

1. To maximise the returns from sale of horn within the constraints imposed by the second aim;
2. To reduce the demand for horn from illegal hunting.

How would the illegal demand be reduced ? Very simply by stealing the customers away from the illegal traders. **This is a critical insight**. At the moment, all of the horn in the international trade is illegal and all of the customers for that horn rely on the black marketeers. Any horn purchased legally from the RHSO has the unique characteristic that it has not caused the illegal killing of a rhino.[11] Logically, the more customers there are that are obtaining their horn from the RHSO, the fewer are the numbers of rhino being killed illegally for any given level of demand. The RHSO has at its disposal a stock of horn which is probably many times larger than any illegal stockpile. Its tools are the volumes of horn it can release onto the market and the prices it can set at each sale.

At this stage we are venturing into the unknown and taking a calculated risk. Until sales actually begin and have been running for some time, it is difficult to predict what will be the best way for the system to manipulate price and demand to achieve the second aim. The effect of setting a price slightly lower than the black market price and, simultaneously increasing the volume of horn entering trade would be to create a climate of uncertainty for the speculators in rhino horn: their stockpiles would begin to look like unattractive investments. The effect of setting a price slightly higher than the black market price might create the conditions for some speculators to abandon the illegal trade because, for very little extra cost, they can obtain horn openly and export it legally. Thus the rôle of the RHSO would be to make life extremely difficult for the black marketeer by continuously moving the goal posts.

I have developed a simulation model[12] which links law enforcement costs to the rate of loss of rhino in the field and enables testing of the effects of changes in the input parameters on both the rate of loss of rhino and, hence, the costs (**Appendix 3**, p23).

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11. Inevitably, there will be Doubting Thomases who will argue that if horns which have been seized from illegal hunters are allowed to be legalised and enter the trade then this will provide the mechanism by which the legal trade will launder substantial amounts of horn derived from ongoing 'rackets'. Some credit needs to be given to those who will conduct the trade. The circumstances under which any seized horn might become legal will be when it has originated from law enforcement operations conducted by the agencies presenting the horn. Any unusual escalation in this source of horn would be noticed and investigated.

12. The model is based on that used in the white rhino management plan for Namibia (Martin 2009).

In the absence of a legal trade, successful protection in the field requires, at a minimum, one 'stick' protecting 3 rhino for 24 hours of the day. Two effects operate at any given level of protection. The first is the initial rate of rhino loss at the given level and the second is the rate of escalation of the loss with time, i.e. for any given level of protection the loss does not remain constant – it increases at that level. This is well demonstrated by the statistics presented by Emslie (2010) for the overall rate of loss from the South African rhino population where the law enforcement level has remained fairly constant with time (about one 'stick' to 15 rhino). The rate of loss increased from 1 rhino every 4 days in 2008 to 1 rhino every 3 days in 2009 and to 1 rhino every day in 2010. The rate of loss escalates at higher rates where the law enforcement effort is low than when it is high.

As stated on the previous page, for the legal trade to work it must 'hijack' customers away from the black marketeers. Because the rate of illegal hunting escalates at any given level of law enforcement, so too must the rate at which the end-users of rhino horn convert to using legal horn. It requires very minor alterations to that rate of escalation in order to make the losses sustainable.

The lowest expectation of the legal trade is that it should hijack sufficient customers away from the black marketeers to ensure survival of the rhino population. In **Table 1** below, the first row shows the numbers of rhino which would have been illegally hunted from the KNP population in the absence of a legal trade at the present law enforcement level (10 rhinos/stick). The population goes extinct in 2023. The next row shows the numbers which have to be hijacked from the numbers in the first row under a legal trade to secure survival of the population. The final row expresses these numbers as a percentage of the first row.

Table 1: Requirement of the legal trade to ensure survival of the KNP rhino population

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Number illegally hunted	141	195	270	375	519	720	998	1,384	1,918	2,659	3,686
Number of rhinos saved	0	7	20	41	75	130	217	351	555	866	1,334
% of nos illegally hunted	0.0	3.6	7.4	10.9	14.5	18.1	21.7	25.4	28.9	32.6	36.2

The condition that the population should avoid extinction requires the lowest values for the slope of the escalation in the number of end-users hijacked from the illegal traders but it produces an undesirable situation. If the population is allowed to drop to very low numbers it takes many years for it to recover to its former level – as many years as it took in the last century to increase the numbers of white rhino to their present level.

If we examine the scenario that –

(a) the worst that should happen to the rhino population is that it should not fall below ecological carrying capacity; and

(b) the expenditure on law enforcement should not increase beyond present levels;

– then it requires some 6% of the present users of illegal rhino horn to convert to using legal horn in the year of inception of the legal trade and this proportion must increase linearly to 60% over the following 10 years (**Table A3.2**, p24).

Of interest is the steepness of the drop-off in numbers hunted illegally after the legal trade has been in effect for several years (**Figs A3.2** & **A3.3**, p26). This is a positive feedback effect resulting from the initial assumptions about the rates of escalation in illegal hunting and in the numbers of end-users hijacked away from the illegal traders. The legal trade causes an increasing reduction in the numbers being hunted illegally each year and, after a certain point on each trajectory, the combination of fewer numbers being hunted illegally with a higher proportion of those numbers being hijacked results in the collapse of the illegal hunting.

Under the assumptions made in the population simulation model for the parameters which will operate when a legal trade is in place (**Appendix 3**), the rhino population will increase briefly near the start while the illegal hunting is still sustainable, then it declines as the illegal hunting escalates and, finally, it recovers as the legal trade starts to 'bite'. At law enforcement level 10 (10 rhinos per stick) the decline takes place fairly soon after the start and then bottoms out in the year 2026 before the population climbs back up to the asymptote of some 17,000 rhino (**FigA3.6**, p28). What may turn out to be an important point in the future management of rhino is that, **if the requirements of level 10 can be met (i.e. the slope of the hijack curve), the recovery is faster than it would be if more money were being spent on law enforcement and the initial rates of population decline were lower**.

A key insight from this modelling is that if the legal trade achieves the requirements for level 10, then **the expenditure on law enforcement need be no more than that for level 10** (i.e. about US$6,000 per rhino). The present expenditure on law enforcement is probably less than that for level 10 but, owing to the shape of the curve constructed for illegal hunting (**Fig.A1.2**, p17), it is not much lower.

Of course, if the legal trade were successful at achieving the reduction in illegal hunting required for the population to remain above carrying capacity, the situation depicted in **Fig.A3.6** is not what would happen. Those rhino populations which were at carrying capacity would immediately be managed to avoid a further increase in their numbers (du Toit 2006) and rhino would be sold and translocated to new properties.[13] This would result in an increase in the range available to rhino, the maintenance of the maximum growth rate for rhino, an increase in the national population of rhino and a generally positive scenario of wealth being generated for all primary stakeholders with rhino on their land.

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13. It could also be anticipated that the live sales price for rhino would increase since the inception of a legal trade would provide a huge incentive for conversion of land to rhino 'farming'.

Costs of Decisions

I now turn to the cost implications of various scenarios. Several scenarios have been simulated (**Table A3.3**, p30 and **Fig.A3.7**, p31). For all of these scenarios, I have assumed that law enforcement is at Level 10 (10 rhinos per stick) and that the factor to scale up from the Kruger National Park population to the South African rhino population is 1.67.

No legal trade

(1) If it were decided not to take the 'risk' of engaging in a legal trade in rhino horn, according to the assumptions underpinning the simulation model, the entire rhino population would be lost over the period 2012-24. This loss, which takes into account the annual increments to the population through breeding and the annual losses from illegal hunting is **US$2.9 billion** (Rands 22 billion). This is the insurance bill that **A** would have to pay to **B** referred to in the final paragraph on page 4.

It is also the moral burden which the decision-takers in the government bureaucracy would have to live with. In any other sphere of commerce, were a bureaucrat to be responsible for the loss of twenty-two billion rands it would result in a national outcry, parliamentary investigations and court charges. Somehow conservation agencies appear exempt from this.

Legal trade beginning in 2013[14]

(2) Under the framework simulated by the population model, the legal trade reduces the number of rhinos killed illegally from 2013-2024 and ensures that the rhino population not only survives but also survives in substantial numbers, i.e. above 16,700 animals when the assumed ecological carrying capacity for Kruger National Park is extrapolated to the national population level. This takes place under an expenditure on law enforcement which is not greatly different to that in place at the moment. The financial saving to the nation from this is some **US$1.6 billion** (R12 billion).

The scenario presented in **Table A3.3** is still a staggering loss of rhino. However, the cost of this loss is reduced from US$2.9 billion (where the rhinos went extinct) to US$1.3 billion (where the rhinos survived) – a saving of US$1.6 billion.

This is, of course, an incomplete financial statement since it does include the income which would have been generated from the sale of rhino horn from 2013-2024. The management of sales is a separate subject dealt with in **Appendix 4** (p32). Suffice it to say at this stage that sales can be organised in such a way that the loss anticipated above (US$1.3 billion) can be nullified by sales over a slightly longer period.

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14. This is the earliest year in which a legal trade could begin. It depends on South Africa and Namibia convincing the Parties to CITES at COP 16 in March 2013 that such a trade is in the best interests of rhino conservation.

Legal trade beginning in 2016[15]

(3) The cost of delaying the submission of a proposal for a legal trade in rhino horn from 2013 to 2016 is evaluated in **Table A3.3.** The same slope of escalation in number of end-users converting to legally obtained horn has been used (**Table A3.1**, p24). The additional cost arising from the continuing loss of rhino between 2013 and 2016 is **US$996 million** (R7.5 billion). This, too, is an amount which DEAT should take seriously – under a fully accountable system, DEAT should be answerable to the nation at large for this huge loss.

Another factor should influence the decision whether or not to submit a proposal for legal trade to the coming CITES COP (March 2013). At present the annual loss of rhino is sustainable but if it continues to escalate at current rates it will become unsustainable within two years (Emslie 2010). If South Africa approaches the CITES Parties with the argument that despite a massive commitment to law enforcement losses are escalating and it needs the legal trade to ensure that the loss does not become unsustainable, there is an excellent chance that it will be successful. However, if it waits until 2016 in the vain hope that it will get on top of the situation and ends up losing the numbers of rhinos predicted in this study, the CITES Parties are likely to view South Africa very differently. It will be seen as a Party which, despite its past conservation record, has now allowed illegal hunting to get out of control and cannot be trusted to implement a legal trade effectively.

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15. The South African Department of the Environment and Tourism (DEAT) has been quoted as saying that 2016 is the earliest year in which a proposal for legal trade could submitted to CITES (CITES COPs are held every three years).

Broad Financial Implications of a Legal Trade in Rhino Horn

In **Appendix 4** (page 32), I have used the results from the simulation modelling to examine how a legal trade might perform. The analysis applies to the Kruger National Park rhino population which is assumed to be some 12,000 animals in 2012.[16] The scenario examined is that where the legal trade hijacks sufficient end-users from the black marketeers to prevent the population falling below 10,000 animals (ecological carrying capacity).

Population numbers

The full effects of a legal trade in reducing the numbers illegally hunted are not felt for several years. The population increases for the first 5 years reaching a peak of 14,300 animals in 2018 and then declines to its lowest value of 10,100 animals in 2027. It then begins to recover reaching an asymptote of some 17,000 animals in 2044.

Illegal hunting

The numbers hunted illegally reach a peak of 1,886 in 2025. Thereafter, the illegal trade is effectively finished, falling to 10 animals per year in 2029. The annual financial loss reaches a peak of **US$150 million** in 2025. These losses do not actually appear in any books of account. The amount of horn which would be required to be sold annually to offset this loss rises to 15 tonnes in 2025 (effectively the entire stock of horn in South Africa). Fortunately, there is no requirement to ensure that the amount from annual horn sales causes the ledger balance to remain at all times 'in the black'.

Sources of horn

Horn is available from natural mortality, from dehorning operations and from existing stocks. Horn from confiscations is automatically incorporated into existing stocks. The amount of horn arising from natural mortality is not large (~ 0.5 tonnes/year). Horn from dehorning operations is assumed to be an average of 0.8kg/rhino/year and, in **Table A4.1** (p35), the proportion of the total population which will be subjected to dehorning has been set at 40%.[17] Of this horn, a small proportion (10%) is added annually to existing stocks of horn. The amount of horn taken from existing stocks and placed on sale in any given year is specified as a percentage of existing stocks (5% in this exercise). The total amount of horn appearing on sale in any given year is the sum of the above amounts and averages about 4.5 tonnes per year.

Horn stocks

The starting stock of horn in 2012 has been obtained by assuming the total stock of horn in South Africa is 16 tonnes and, of this, about 9.6 tonnes 'belongs' to KNP. Thereafter, the annual stock of horn is decreased by the 5% appearing in sales but increased by the 10% of the total amount of horn arising from dehorning. In the scenario depicted, this results in a slowly increasing stock over the full period (11.9 tonnes in 2044). The strategy for management of this stockpile would rest with the RHSO and, by small variations in the percentage appearing on sales, the overall stock can be made to increase or decrease in the long term. It might be sound strategy to always maintain a strong 'capital base'.

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16. It can be scaled up to the national level by using a factor of 1.67.

17. This percentage is probably far higher than will be applied in KNP and was selected purely for demonstration purposes.

Annual income from sales

The sale price (US$10,000/kg) has been fixed over the duration of the spreadsheet (**Table A4.1**, p35) and it results in an average annual income of about US$45 million. In practice, the RHSO would vary the price from sale to sale depending on the immediate objectives. The cumulative gross income earned from sale of horn over the period 2013-2044 is US$1.4 billion. The average income per rhino per year in this scenario is around US$3,100. It can be raised to US$4,000 by increasing the dehorning percentage to 50% and increasing the percentage of total stocks placed on sale to 6%.

Ledger balance

This is the reconciliation of the full value of rhino losses with the gross income earned from horn sales over the period 2012-2044, i.e. what would be shown by any ordinary bank statement. I have pointed out that, under present accounting systems, the losses of rhino to illegal hunting do not 'appear in the books'. When they are made to appear in the books, it transpires under the given scenario that after an initial positive balance up to 2020 the ledger shows a massive deficit from 2021-2039. This is the period where the losses of the past are being paid for. The mortgage is acquitted in 2040 and from then onwards the 'true account' is 'in the black', ending with a credit of US$570 million in the year 2050.

All of the income referred to so far is gross income. It does not take into account the costs of protecting the rhino. An average income of US$3,100 per rhino (see above) would more or less meet the present allocation for rhino protection in Kruger National Park.

A key variable in this analysis is the proportion of the total rhino population which is subject to a dehorning regime. The horn generated from dehorning is by far the largest component of the total horn presented for sale in **Table A4.1**. If all rhino were subject to dehorning, the gross annual income per rhino rises to over US$8,000 and would not only meet all protection costs but would also leave SANParks with a substantial profit. To some extent this is academic: SANParks is unlikely to manage its white rhino for the maximum production of rhino horn. However, it is a measure of what a private landholder might expect from a 100% dehorning regime.

If the legal trade in rhino horn works and reduces illegal hunting to a very low level (as predicted by the scenarios presented in this study), the actual costs of rhino protection may be significantly reduced – in which case the returns from sale of horn become pure profit.

A final consideration is the price which rhino horn will fetch on the legal market. The analysis in **Table A4.1** has used a fixed price of US$10,000/kg throughout but manipulations of the price by the RHSO may result in considerably higher figures. At present, the black market price in South Africa is some US$10,000/kg but the amount which the end-user of rhino horn is paying may be between 4-6 times this amount. If the legal trade is successful in reducing the length of the supply chain which exists in the black market and horn can be delivered to the consumer more directly it is possible that a greater profit can be made at the 'farm gate'.

Summing up

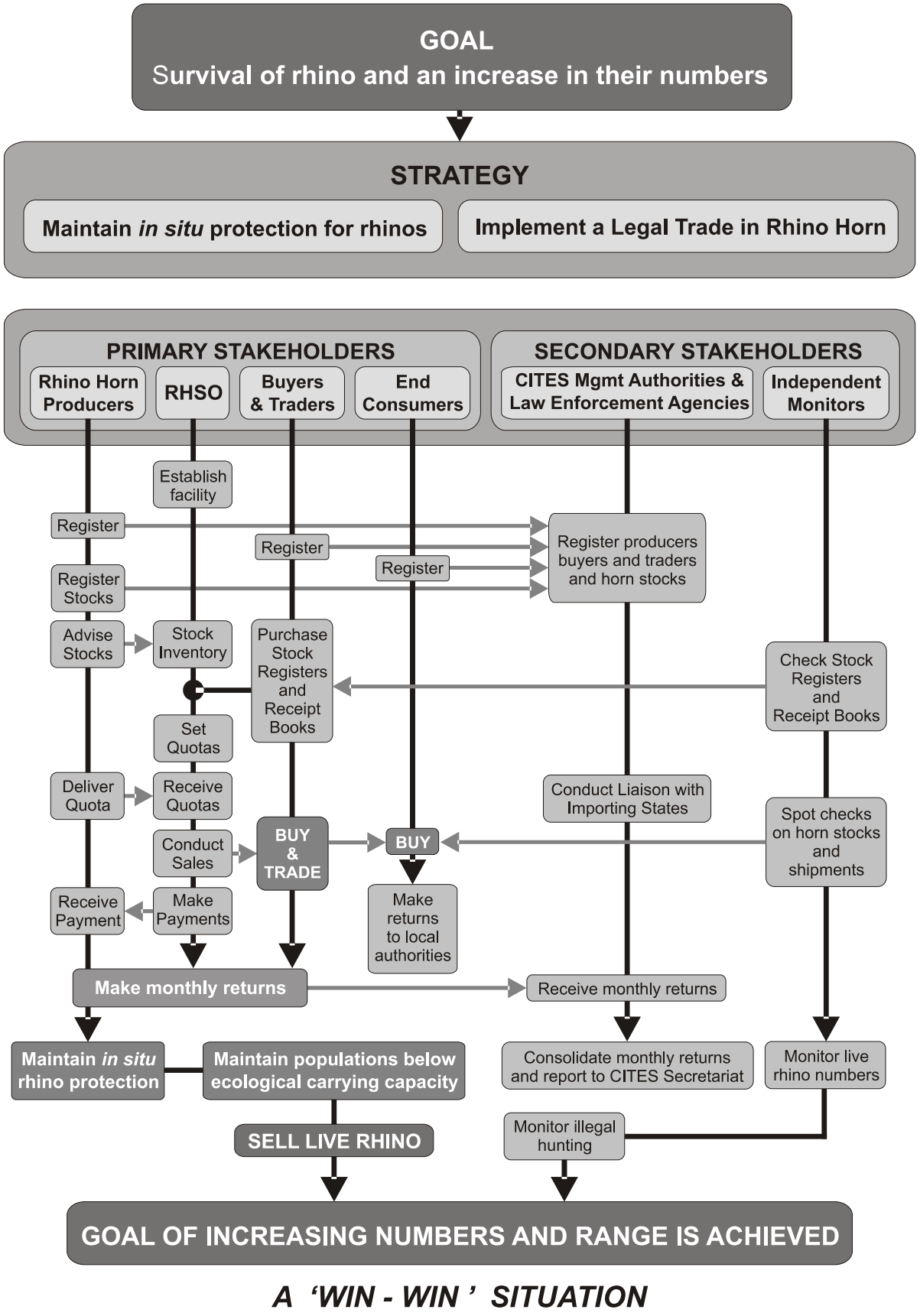
Unlike the 'more-of-the-same' scenario, the 'radical change' scenario offers space for experimentation with very little risk involved. If the legal trade is not achieving its aim, it is easy to stop it. The 'more-of-the-same' scenario has no fall-back position – it has nailed its colours to the mast and is committed to doing the right thing all the way to the extinction of rhino.

The pessimist's position is that venturing into a legal trade carries the risk of things getting even worse than they are now. The illegal hunting from the South African rhino population has reached the point where, if it continues at its present rate, it will be unsustainable within two years and extinct within 22 years. It is difficult to conceive of a more grave situation than this.

The optimist would look at the potential win-win situation. The resource (rhino horn) is incredibly valuable. There is a substantial demand for the resource. Exploited shrewdly, this demand could provide the wealth that resulted in increasing investment in rhino, transformed land use in southern Africa and achieved an explosion in rhino population numbers.

Evaluating the two scenarios, we are left with Hobson's Choice.

Figure 2. 'Radical Change' strategy – outcomes



Appendix 1

The Kruger National Park Rhino Population

Population Dynamics and Illegal Hunting

The analysis here applies to the white rhino population which forms 95% of the rhino numbers in the park. Conditions for the black rhino population will not be exactly the same but the outcome is unlikely to influence the overall result greatly. A simulation model has been developed which crudely mimics the population dynamics and illegal hunting process. The model provides the initial conditions against which the effects of a legal trade can be tested.

Carrying capacity

Martin (2009) developed a generalised formula for predicting the stocking level for white rhino at ecological carrying capacity based on rainfall (expressed in millimetres) –

$$\textit{Stocking level} = 10^{(A.Rainfall + B)} \text{ km}^2\text{/rhino}$$

– where ***A*** and ***B*** are constants with the values ***A*** = -0.00229 and ***B*** = 1.643

Assuming an average rainfall of 600mm for the park, this predicts a stocking level of 1.86 km^2/rhino and, for the total area of 18,985km^2, a population of 10,219 rhino at carrying capacity. The present population is about 11,500 (Mike Knight, pers. comm. Sept.2011). Given the rainfall gradient from north to south across the park, no great accuracy should be attached to this 'ballpark' figure. However, it suggests that the rhino population is close to carrying capacity.

In the simulation model, I have incorporated a suite of homeostatic mechanisms which apply negative feedback to the population growth once it has exceeded ecological carrying capacity.

Table A1.1: Population homeostatic parameters

Population condition	Age at first conception	Intercalving interval	Adult mortality	Juvenile mortality
Below carrying capacity	6.5 years	30 months	1%	8%
At asymptote	7.8 years	36.4 months	3.2%	39%

The changes in the population reproductive parameters are proportional to the amount by which ecological carrying capacity has been exceeded and cause the population to stabilise at an asymptote of 16,770 animals. The population initially overshoots this asymptote, peaking at about 17,333 animals in 2031 and then shows damped oscillations about the asymptote before levelling off around 2100. For the purposes for which the model is intended, the population trajectory shown in Fig.A1.1 is not critical.

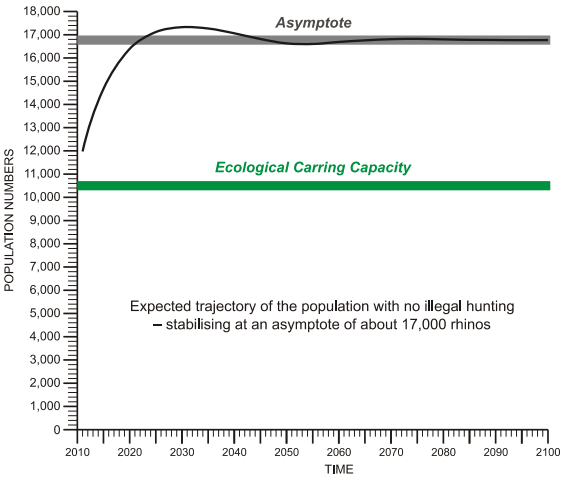


Figure A1.1: Population trajectory

In this section I develop relationships between law enforcement effort, cost, and loss of rhino. The assumptions underpinning the relationship are –

(1) The highest level of security which can be provided is where each rhino is protected 24 hours of the day by permanent guards. I define a 'stick' as two guards. For 24 hour protection, three sticks are needed, each stick working an 8 hour shift. At an annual salary of US$9,850, the cost of one stick is US$19,700 and for three sticks it is US$59,100. Even at this level of protection, I assume that there will be a small loss of rhino (10 per year).

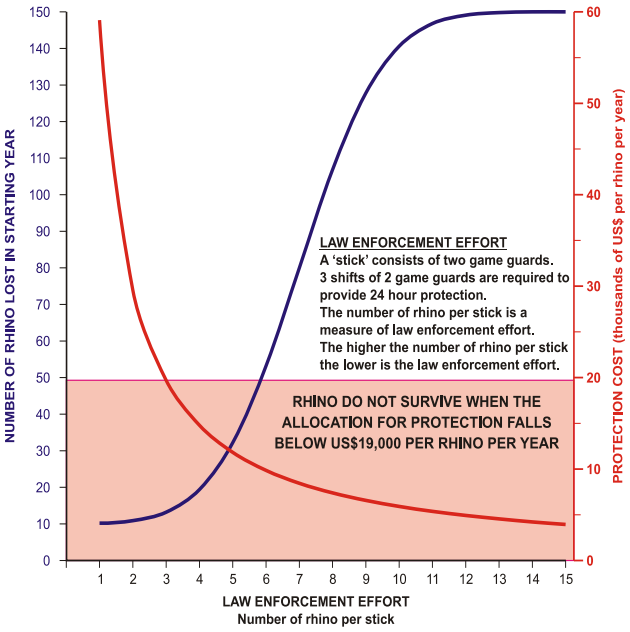
(2) As the level of protection is decreased (i.e. 2 rhinos per stick, 3 rhinos per stick and so on) the loss of rhino increases. A logistic curve has been used in **Fig.A1.2** to define the relationship. The present loss of rhino in Kruger is assumed to be 150 per year and this is occurring at an annual field budget of about US$47 million.[18] For 12,000 rhino, this works out to an expenditure of slightly less than US$4,000 per rhino per year – which corresponds to a law enforcement effort of about 15 rhino per stick. The cost per rhino for various levels of law enforcement are given in **Table A1.2** and **Fig.A1.2** below.

Table A1.2: Protection costs

No.of rhinos	**12,000**
Cost/stick	**$19,700**

Number of rhinos/stick	Cost/rhino US$	Total cost of protection	Initial loss
1	$59,100	$709,200,000	10
2	$29,550	$354,600,000	11
3	$19,700	$236,400,000	13
4	$14,775	$177,300,000	19
5	$11,820	$141,840,000	32
6	$9,850	$118,200,000	53
7	$8,443	$101,314,286	80
8	$7,388	$88,650,000	107
9	$6,567	$78,800,000	128
10	$5,910	$70,920,000	141
15	$3,940	$47,280,000	150

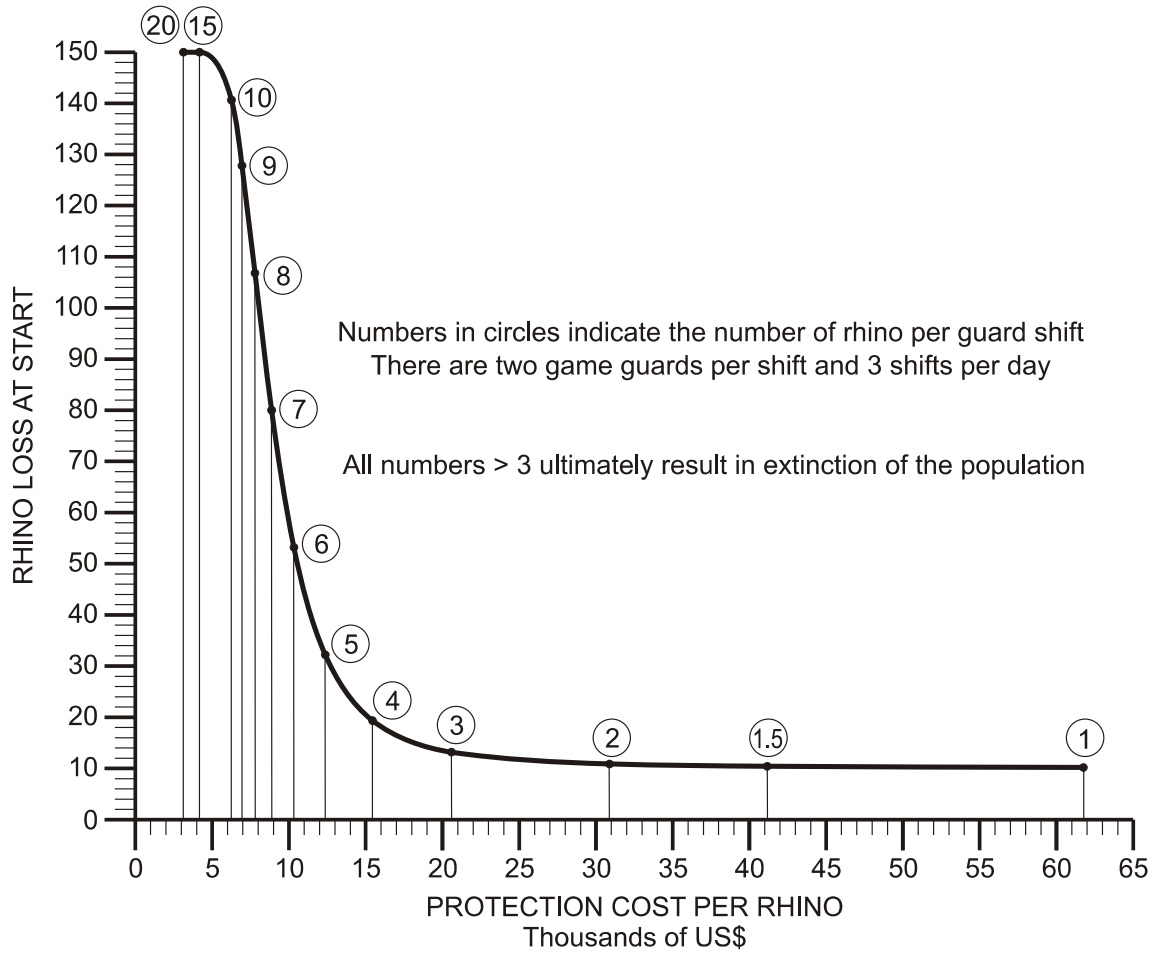
Fig.A1.2: Law enforcement effort & loss



An alternative representation of this figure is given in Fig.A1.3 on the next page.

18. The actual budget is less than this (about US$43 million). I have increased it to allow for the considerable extra funding being made available for military support for rhino antipoaching operations.

Figure A1.3: Loss of rhinos in starting year versus protection cost per rhino



(3) In the figure above, the Y axis shows the expected baseline loss of rhino in the 'starting year'. The law enforcement effort in Kruger National Park has remained more or less constant for the past 5 years but the number of rhino lost has escalated each year. This indicates that there are two components to the rhino loss: the first is the initial rate of loss for any given level of law enforcement effort and the second is the rate of escalation of that loss with time.[19]

There are few data to work with in constructing a set of curves showing the rate of escalation with time. We have already postulated that at the highest levels of law enforcement (1-3 rhinos per stick) the expected initial loss is low and, accordingly, the escalation in the rate of loss can also be expected to be low. At the other end of the scale, Emslie (2010) estimated that when the loss of rhino from the total rhino population in South Africa reached 300 in 2010, it would require only 2 years for the loss to become unsustainable. For Kruger National Park the loss would be unsustainable when it exceeds about 600 rhinos per year (see first paragraph on page 1). I have designed a set of curves where the loss of rhinos at a law enforcement level of 15 rhinos/stick exceeds 600 per year in the year 2015. This is slightly lower than Emslie's figure but it avoids being alarmist. The curves for intermediate levels of law enforcement effort fall between the two extremes (**Fig A1.4**, next page).

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19. In calculus terms, the initial rate of loss is dy/dt. The escalation in loss thereafter is d^2y/dt^2.

The formula I have used for the escalation of illegal hunting with time is –

$$\textit{Rhino loss} = Nr \,.\, e^{\,(B\,.\,(Nr - 10)/Nr)\,.\,(Y - Y_0))}$$

where –

Nr is the initial number of rhinos expected to be lost at a given law enforcement level;

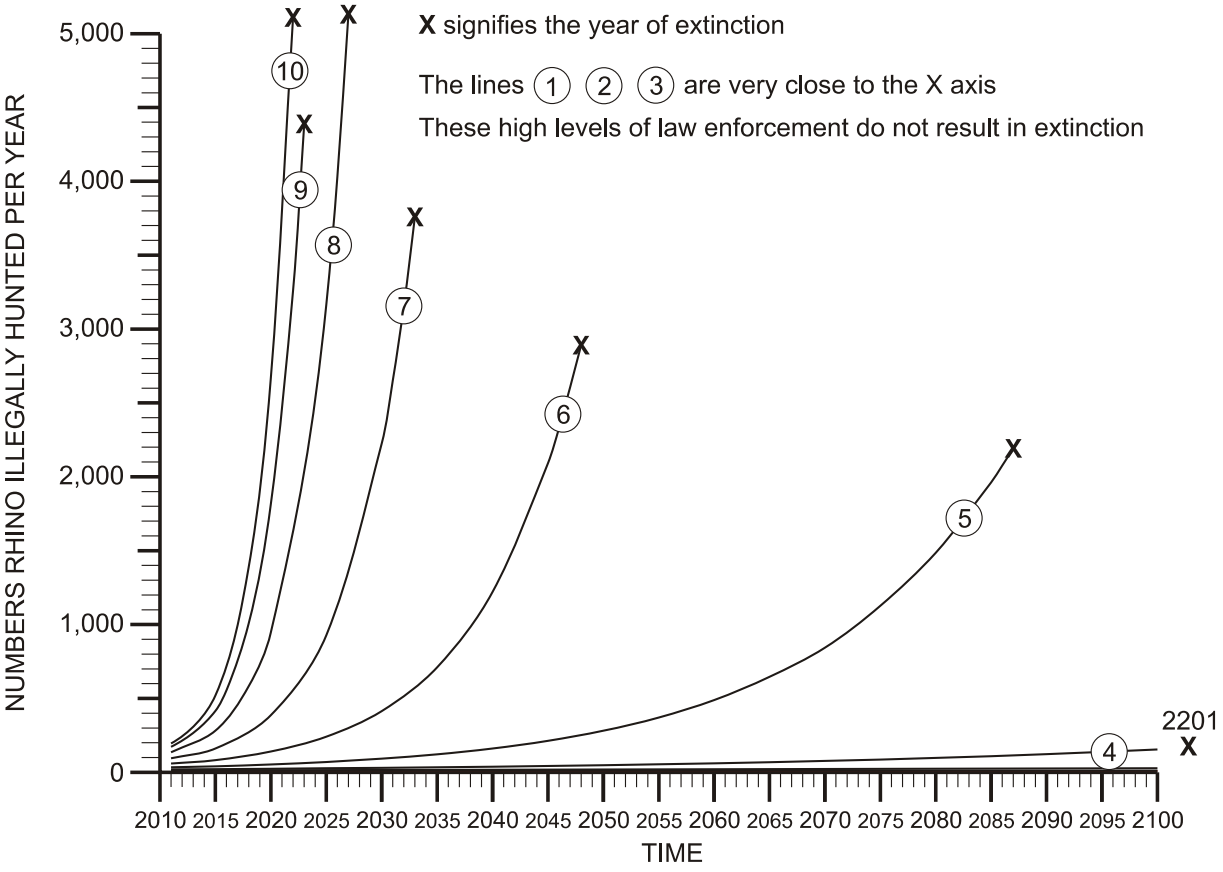
B is a constant (= 0.025);

Y is the year concerned;

Y_0 is the starting year

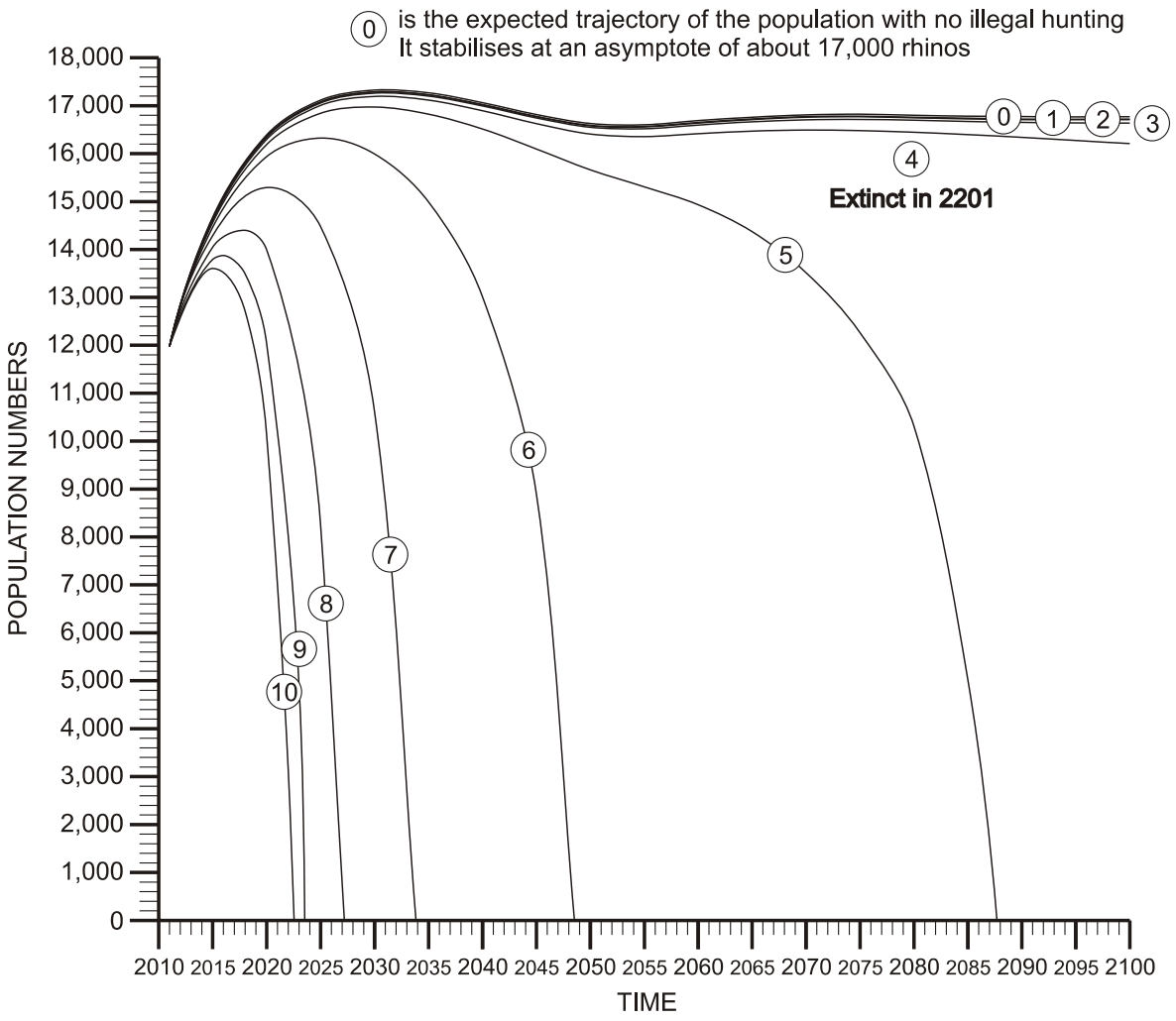
The curves generated by this formula for different levels of law enforcement are shown in **Fig.A1.4** below –

Figure A1.4: Losses of rhino related to level of law enforcement over time



The numbers shown within circles refer to the number of rhino per stick. With the exception of law enforcement levels 1, 2 & 3, all of these curves ultimately result in population extinction. It takes longest for level 4: extinction only occurs in the year 2201. In **Fig. A1.5** on the next page the populations trajectories are shown for each of these levels of law enforcement.

Figure A1.5: Population trajectories for various levels of law enforcement



These conditions set the stage for the next scenario which simulates the modifying effects of a legal trade in rhino horn. We will be seeking the extent to which each trajectory has to be modified into to make it sustainable.

I conclude this Appendix with the necessary caveat that the framework constructed here is an edifice built with flimsy materials. There are few data available for it to be made more robust. The quote below is from Jared Diamond's book *Collapse* (Diamond 2006, p349). In reviewing the paradoxical behaviour of the Dominican Republic's famous president Balaguer (1906-2002), Diamond remarks –

> *The struggle to understand Balaguer reminds me that history, as well as life itself, is complicated; neither life nor history is an enterprise for those who seek simplicity and consistency.*

To this might be added that, whilst history may be complicated, attempting to make predictions for the future is doubly so.

Appendix 2

How would a legal trade in rhino horn operate ?

There are a diversity of views on this subject ... even amongst the proponents of such a trade. The mechanisms outlined below are entirely those proposed by the author – who would be willing to take into account any variations which would improve the system. The strategy would be to make it very easy to trade legally and, conversely, unattractive to trade illegally.

1. All horn would be held by a single selling organisation in South Africa established for the purpose of legal rhino horn sales (e.g. **RHSO** – The Rhino Horn Selling Organisation). The RHSO would be accountable to but independent of government. The costs of this organisation would be met by a levy on sales.

2. Only rhino horns originating from Namibia and South Africa would be sold.

   (a) Each horn will be marked with a seal which gives the country of origin and a unique serial number;

   (b) Each horn will carry a small transponder which can be interrogated with a radio transmitter;

   (c) Each horn will have a recorded chemical signature based on its DNA structure.

   It will be very difficult for any illegal horn to infiltrate the system – either at the point of sale or anywhere along the path to the end-consumer.

3. All legally obtained horn in Namibia and South Africa would be eligible for sales. This would include –

   (a) Horns arising from natural mortality;

   (b) Horns seized from illegal traders; and

   (c) Horns obtained from dehorning in State Protected Areas, private and communal land.

   All of these horns would have to satisfy the requirements of 2 (a) - (c) above before they could be admitted to RHSO sales.

4. Sales would be conducted by the method used by de Beers' Central Selling Organisation for diamonds.

   (a) Horn would be made up into parcels (say 10kg per parcel) and the price for each parcel would be set by the RHSO.

   (b) Sales would be held at, say, monthly intervals in South Africa and only registered buyers (see below) would attend the sales.[20]

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20. Observers at sales would be at the discretion of the RHSO.

5. Persons, companies or organisations wishing to buy rhino horn at the RHSO sales will register as **buyers** with the CITES Management Authority in his/her/its country (buyers and traders from states which are not Parties to CITES are excluded). Registration will be very simple and will require –

   (a) the particulars of the individual, company or organisation (name, address, national registration number);

   (b) a statement whether they are buyers, traders or both;

   (c) the purchase of a stock register in which will be recorded the details of all purchases and sales of rhino horn;

   (d) the purchase of a book of receipts; and

   (e) the presentation and registration of their personal seal.[21]

6. Persons, companies or organisations wishing to trade in rhino horn will register as **traders** with the CITES Management Authority in his/her/its country.[22] Traders will only be able to purchase rhino horn from accredited buyers or other registered traders. All buyers would automatically be treated as traders but the reverse is not true. All traders would comply with steps 5(a)-(e) above.

   (a) All trade would be conducted through a system of traceable receipts.

   (b) Copies of current sheet(s) in each stock register would be submitted annually to the CITES Management Authorities in the relevant countries. These would be consolidated and submitted to a designated person in the CITES Secretariat.

   (c) The costs of administering this system would be met from the sales of stock registers and receipt books.

6. The returns from sales would accrue directly to the agencies or individuals who put rhino horn on sale with the RHSO.

7. The opportunities for corruption under such a system are very low indeed.

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21. It is intended that all trade documentation is stamped with a personal seal such as those presently used in Asia (e.g. *Hanko* in Japan).

22. South Africans and Namibians would be allowed to register as buyers and/or traders.

Appendix 3

The Kruger National Park Rhino Population

Effects of a Legal Trade on Illegal Hunting

The mechanism by which a legal trade would influence the number of rhinos illegally killed is to replace a part of the quantity of rhino horn being sold illegally to the end-customers with horn obtained legally. For any given level of demand, this would effectively reduce the numbers of rhino being killed illegally.

In **Appendix 1**, I linked demand to law enforcement effort. At very high levels of law enforcement effort (1,2 or 3 rhinos per 'stick' guarding them), the initial losses are low and the rate of escalation of those losses are low. However, the costs of such efforts are very high (>US$20,000 per rhino per year). At level 4 of law enforcement effort (4 rhinos per 'stick'), the prediction is that the rhino population would decline very slowly to extinction taking some 190 years to get there. The cost of protection per rhino at level 4 is about US$15,000 per year. It requires very little reduction in the numbers hunted illegally (i.e. in the number of end-users of illegal rhino horn hijacked from the black marketeers) to make Level 4 sustainable and, in the analysis which follows, I have ignored Level 4 because we are seeking much lower costs of protection. So the focus in this analysis is on Levels 5-10 (5 to 10 rhinos per stick) for which the costs of protection vary from US$12,000 to US$6,000 per year (**Table A1.2**, p17). Clearly, the less that has to be spent on law enforcement to ensure survival, the greater are the benefits for all stakeholders.

Because the level of illegal hunting at any given level of protection escalates with time (**Fig.A1.4**, p19), the proportion of the numbers of end-users converting to legal horn also has to escalate with time. Although I assumed that this escalation was exponential for the numbers illegally hunted (**Appendix 1**, top of page 19), I have assumed a simple linear rate of increase for the numbers of end-users converting to legal horn over time –

$$\textit{Rhino required to be hijacked from illegal trade} = Nr \,.\, A \,.\, (Y - Y0)$$

where –

Nr is the number of rhinos expected to be lost at a given law enforcement level;

A is the slope of the line;

Y is the year concerned;

Y_0 is the starting year

The choice of slope is dependent on the goal being set for the legal trade. If it is merely required that rhino survive extinction, this gives the lowest slope in the formula above. If it is required that the numbers of rhino do not at any time drop below half of ecological carrying capacity, this gives a slightly higher slope (i.e. more rhino have to be hijacked from the illegal trade). The highest level I have tested is the requirement that rhino numbers should not fall below ecological carrying capacity – which gives the highest values of slope. The various values of slope for these requirements are shown in **Table A3.1** on the next page.

The table below is intended to apply to the Kruger National Park rhino population. It has been assumed that ecological carrying capacity for the Park is 10,000 rhino (**Fig.A1.1**, p16) and therefore half of carrying capacity is 5,000 rhino.

Table A3.1: Slopes of lines which determine the numbers of rhino taken away from the illegal trade by the legal trade

Law Enforcement Level ➤	5	6	7	8	9	10
Survival	0.00760	0.01440	0.02190	0.02866	0.03356	0.03618
> 50% Carrying Capacity	0.00844	0.01730	0.02839	0.03956	0.04844	0.05386
> Carrying Capacity	0.00865	0.01800	0.03102	0.04428	0.05521	0.06215

All of the above levels of law enforcement effort (5-10 rhinos per stick) result in extinction of the rhino in the absence of a legal trade (**Fig.A1.5**, p20). The percentages of the numbers which would have been hunted illegally (**Fig.A1.4**, p19) required to rectify this situation are relatively small (**Table A3.2** below). The legal trade effectively replaces this percentage with legally obtained horns and, hence, fewer rhino are killed.

Table A3.2: Percentages of the numbers of rhino required to be hijacked from the illegal trade in order for the population to remain above ecological carrying capacity

Slope required to keep rhinos above carrying capacity

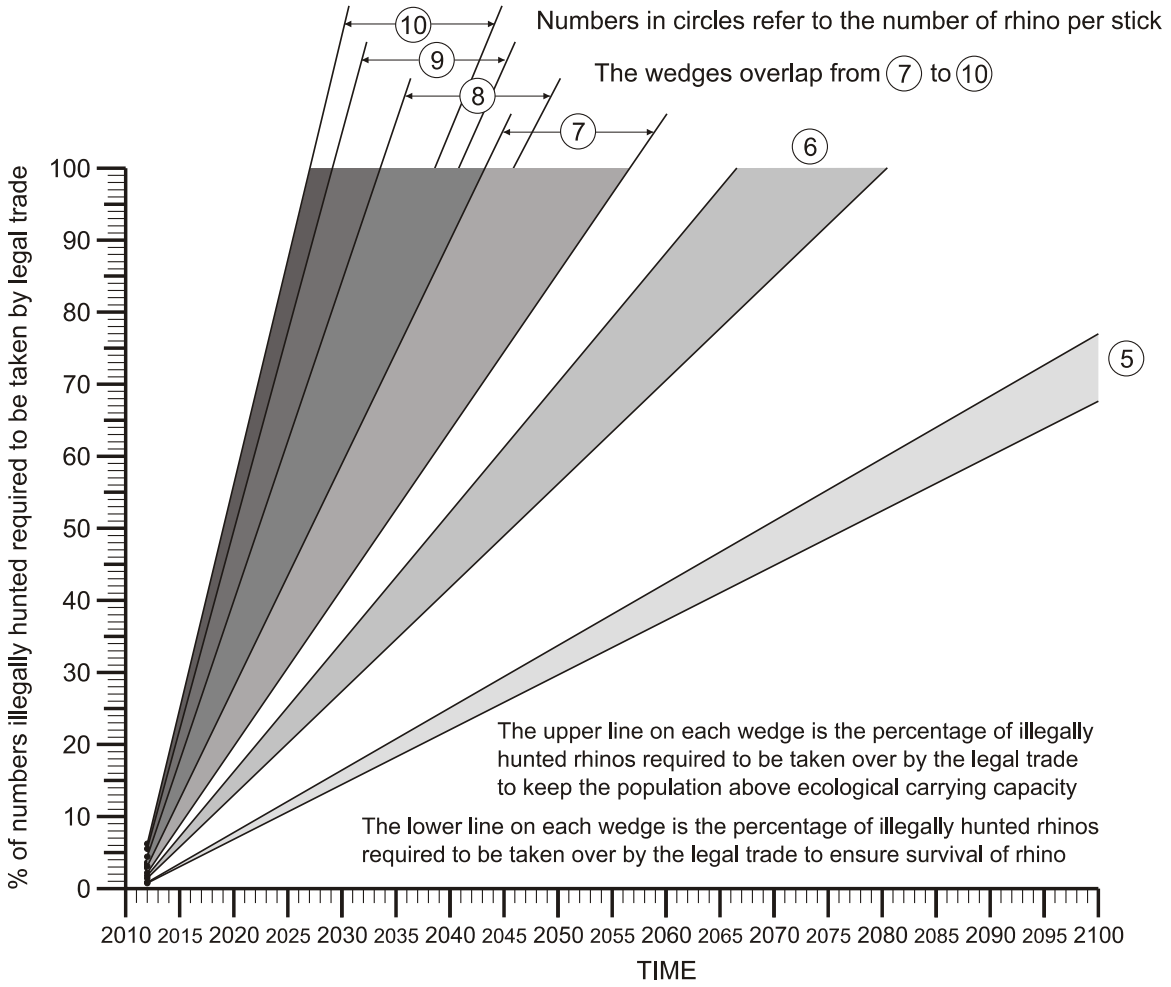
0.00865	0.01800	0.03102	0.04428	0.05521	0.06215

Law Enforcement Level (number of rhinos per stick)

Year	5	6	7	8	9	10
1	0.9	1.8	3.1	4.4	5.5	6.2
2	1.7	3.6	6.2	8.9	11.0	12.4
3	2.6	5.4	9.3	13.3	16.6	18.6
4	3.5	7.2	12.4	17.7	22.1	24.9
5	4.3	9.0	15.5	22.1	27.6	31.1
6	5.2	10.8	18.6	26.6	33.1	37.3
7	6.1	12.6	21.7	31.0	38.6	43.5
8	6.9	14.4	24.8	35.4	44.2	49.7
9	7.8	16.2	27.9	39.9	49.7	55.9
10	8.7	18.0	31.0	44.3	55.2	62.2

The results of applying these percentages to the numbers of rhinos needed to be 'hijacked' by the legal trade are shown in **Fig.A3.1** on the next page.

Figure A3.1: Percentages of rhino 'hijacked' from the illegal trade by the legal trade



A frequently asked question is "how long would it take before the effects of a legal trade started to reduce the numbers of rhinos hunted illegally"? I have avoided needing to make assumptions about this simply by treating the whole process as continuum where a certain percentage (determined by the slopes of the lines generated in Table **A3.1**) of the rhinos which would have been hunted illegally is replaced by rhinos which have provided legal horns. These slopes were obtained by repeated iterations of the simulation model until the required condition (e.g. that rhino numbers should not drop below ecological carrying capacity) was satisfied.

The maximum numbers of rhinos which can be hunted illegally if the condition is that rhino should survive extinction is shown in **Fig.A3.2** and, for the condition that rhino numbers should not fall below ecological carrying capacity, the maximum numbers are shown in **Fig. A3.3** (next page). The slopes of escalation of the numbers of rhino being hijacked from the illegal trade are those given in **Table A3.1.** Both sets of curves show a pattern of rising numbers after the inception of the legal trade followed by a decline in numbers to a low level (10 animals). In all years, the numbers remain below those shown in **Fig.A1.4** (p19) which, for law enforcement levels 5-10, led to extinction of the rhino (the red lines in **Figs. A3.2** & **A3.3**). The condition that rhino should remain at all times above 10,000 animals (carrying capacity) obviously requires fewer rhinos to be killed illegally than the condition that rhinos should simply survive.

Figure A3.2: Numbers of rhino hunted illegally with a legal trade and the population surviving extinction

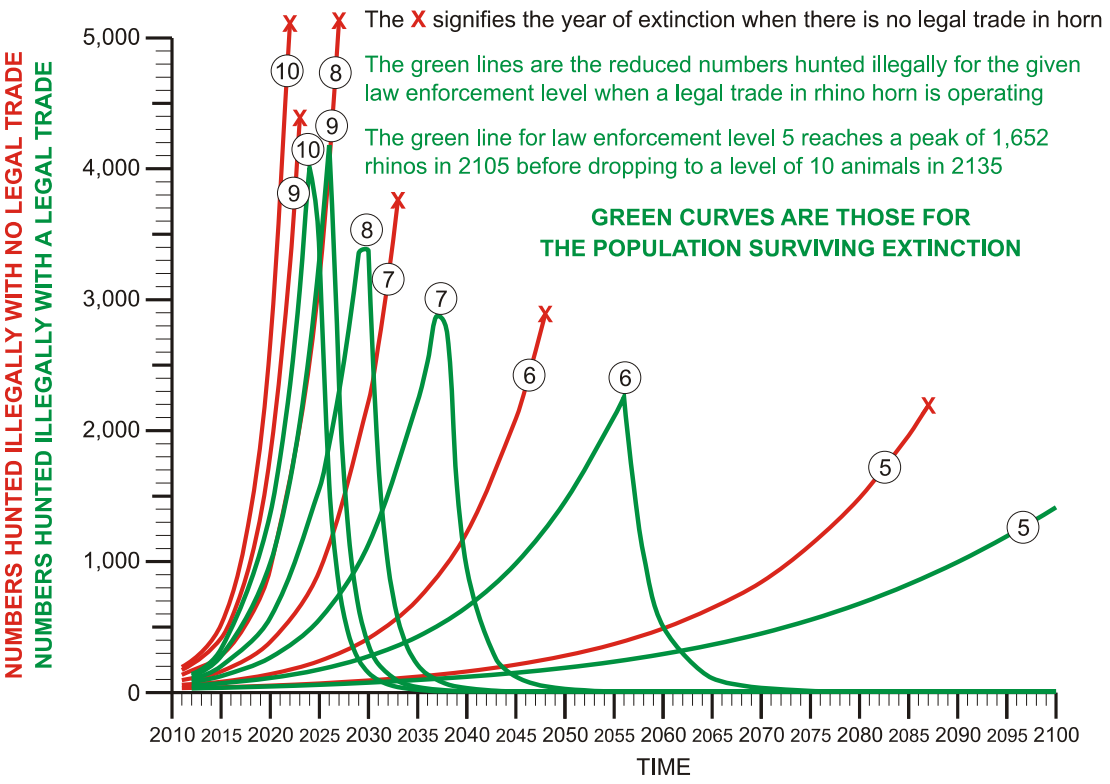
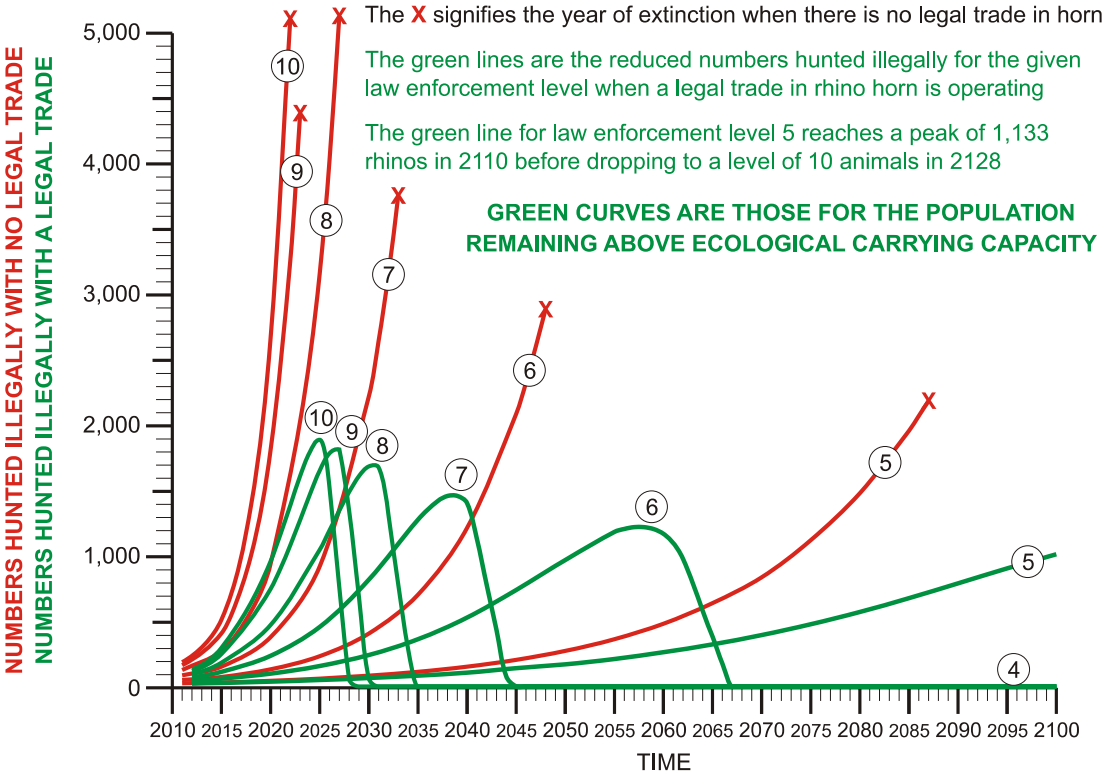


Figure A3.3: Numbers of rhino hunted illegally with a legal trade and the population remaining above ecological carrying capacity

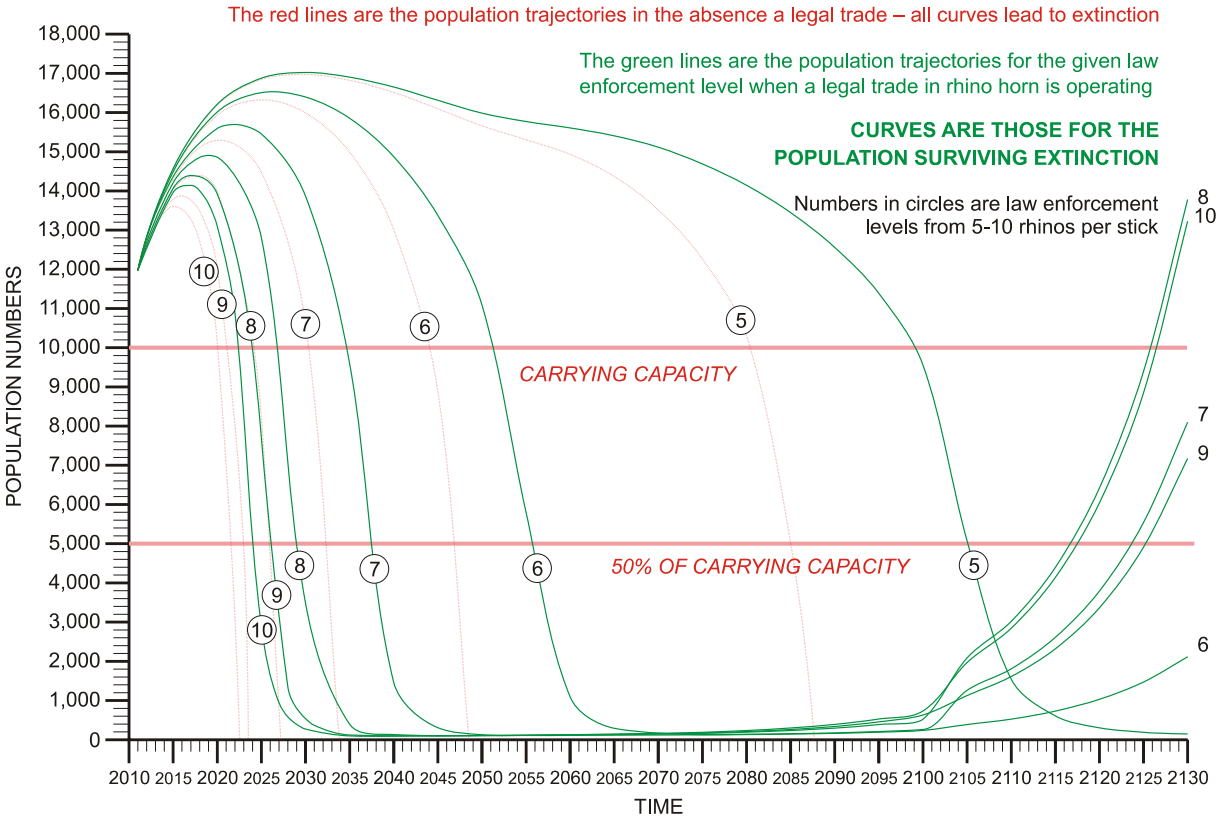


Of interest in the figures on the previous page is the steepness of the drop-off in numbers hunted illegally after the legal trade has been in effect for several years. This is a positive feedback effect resulting from the initial assumptions about the rates of escalation in illegal hunting and in the numbers of end-users hijacked away from the illegal traders. The legal trade causes an increasing reduction in the numbers being hunted illegally each year and, after a certain point on each trajectory, the combination of fewer numbers being hunted illegally with a higher proportion of those numbers being hijacked results in the collapse of the illegal hunting.

In the next three figures I show the population trajectories for the conditions that rhino should (a) survive extinction (**Fig.A3.4**), (b) should not drop lower than half of carrying capacity (**Fig.A3.5**) and (c) should remain above carrying capacity over the full period (**Fig.A3.6**).

The condition that the population should avoid extinction (**Fig.A3.4** below) requires the lowest values for the slope of the escalation in the number of end-users hijacked from the illegal traders but it produces an undesirable situation. If the population is allowed to drop to very low numbers it takes many years for it to recover to its former level – as many years as it took in the last century to increase the numbers of white rhino to their present level.[23]

Figure A3.4: Legal trade – Population numbers with the population surviving extinction



23. If the population drops to 100 animals before it begins to increase, at a population growth rate of 6% it takes 80 years before it once more exceeds an ecological carrying capacity of 10,000 animals.

Figure A3.5: Legal trade – Population numbers with the population remaining above half of ecological carrying capacity

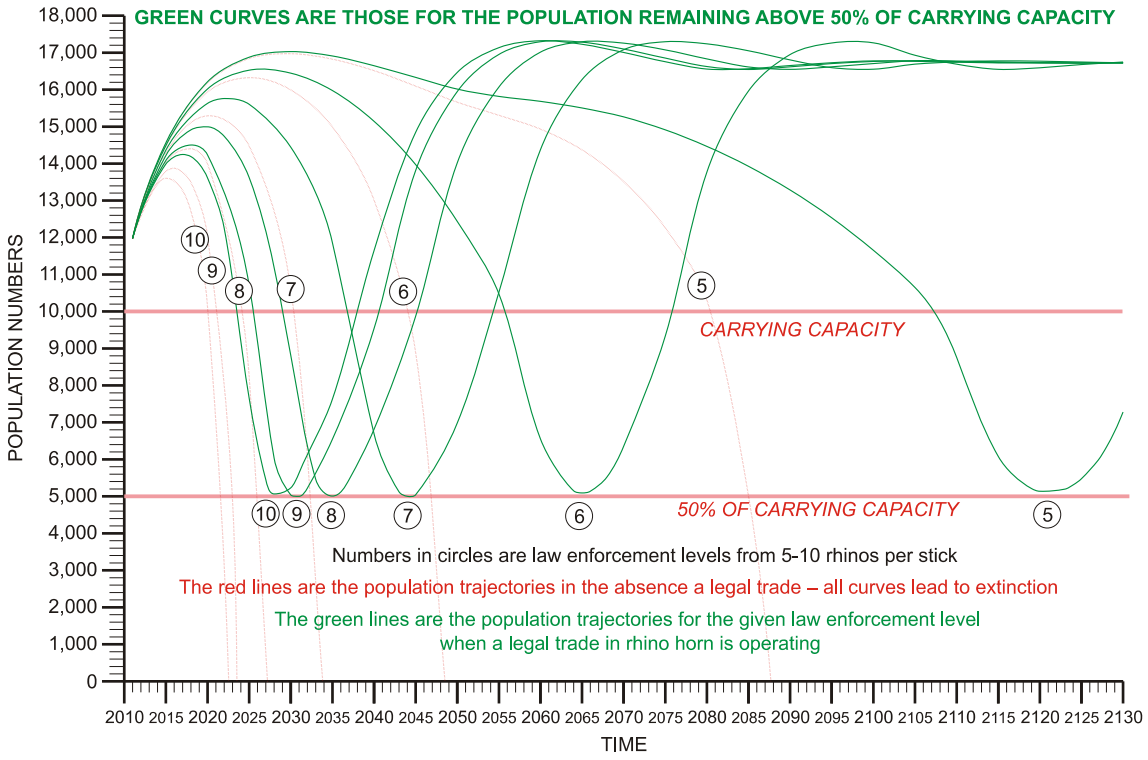
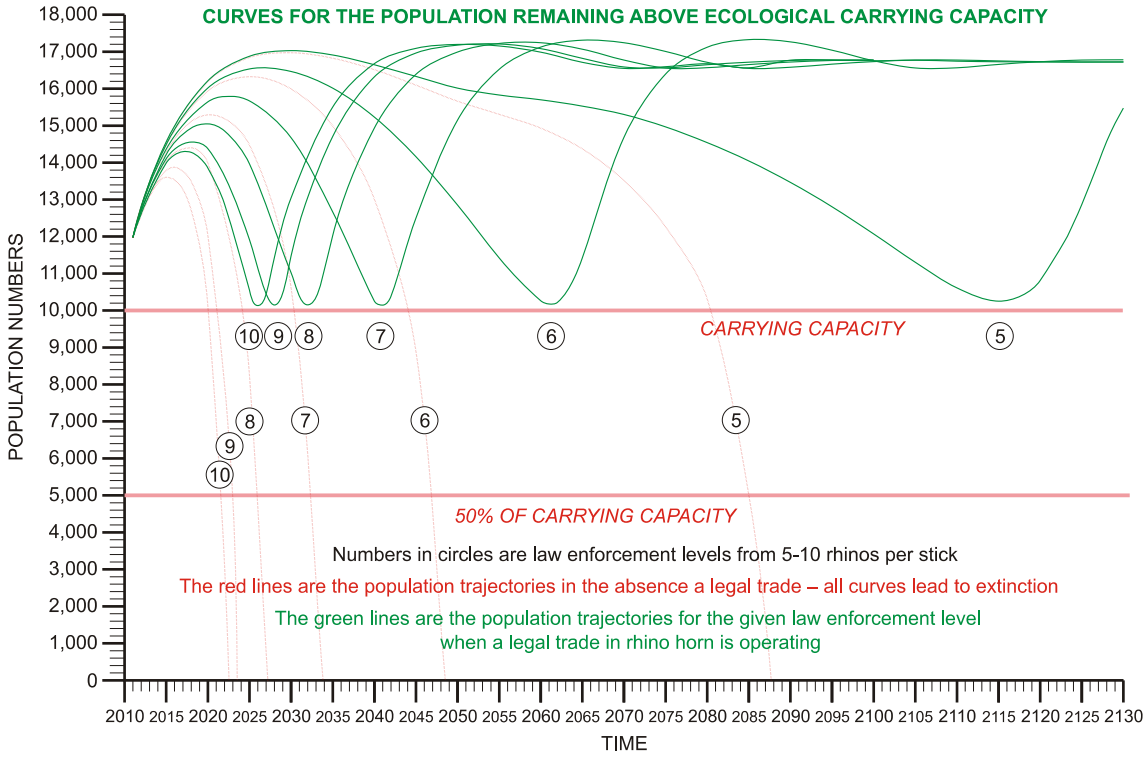


Figure A3.6: Legal trade – Population numbers with the population remaining above ecological carrying capacity



There are several observations to be made on the curves in the previous two figures. In all cases, the rhino population increases briefly near the start, then declines as the illegal hunting escalates and then recovers as the legal trade starts to 'bite'. At law enforcement level 5 (5 rhinos per stick) the decline is protracted because of the low rate of increase of the illegal hunting. At law enforcement level 10 (10 rhinos per stick) the decline takes place fairly soon after the start and then bottoms out in the year 2027 before the population climbs back up to the asymptote of some 17,000 rhino. What may turn out to be an important point in the future management of rhino is that, **if the requirements of level 10 can be met (i.e. the slope of the hijack curve), the recovery is faster than it would be if more money were being spent on law enforcement and the initial rates of population decline were lower**.

A key insight from this modelling is that if the legal trade achieves the requirements for level 10, then **the expenditure on law enforcement need be no more than that for level 10** (i.e. about US$6,000 per rhino). The present expenditure on law enforcement is probably less than that for level 10 but, owing to the shape of the curve constructed for illegal hunting (**Fig.A1.2**, p17), it is not much lower.

Of course, if the legal trade were successful at achieving the reduction in illegal hunting required for the population to remain above carrying capacity, the situation depicted in **Fig.A3.6** is not what would happen. Those rhino populations which were at carrying capacity would immediately be managed to avoid a further increase in their numbers (du Toit 2006) and rhino would be sold and translocated to new properties. This would result in an increase in the range available to rhino, the maintenance of the maximum growth rate for rhino, an increase in the national population of rhino and a generally positive scenario of wealth being generated for all primary stakeholders with rhino on their land.

So far little has been said about the costs of these various scenarios. There are several scenarios which need to be simulated (**Table A3.3**, next page and **Fig.A3.7**, p31). For all of these scenarios, I have assumed that law enforcement is at Level 10 (10 rhinos per stick) and that the factor to scale up from the Kruger National Park population to the South African rhino population is 1.67.

No legal trade

(1) If it were decided not to take the 'risk' of engaging in a legal trade in rhino horn, according to the assumptions underpinning the simulation model the entire rhino population would be lost over the period 2012-24. This loss, which takes into account the annual increments to the population through breeding and the annual losses from illegal hunting is **US$2.9 billion** (Rands 22 billion). This is the insurance bill that **A** would have to pay to **B** referred to in the final paragraph on page 4.

It is also the moral burden which the decision-takers in the government bureaucracy would have to live with. In any other sphere of commerce, were a bureaucrat to be responsible for the loss of twenty-two billion rands, it would result in a national outcry, parliamentary investigations and court charges. Somehow conservation agencies appear exempt from this.

Table A3.3: Cost of illegal hunting under various scenarios

Law enforcement level 10 (10 rhinos per stick)

Value of a rhino US$ 80,000 **1US$ = R7.5**

RHINOS ILLEGALLY HUNTED IN KNP

Year	No Legal Trade	Legal Trade 2013	Legal Trade 2016
2012	141	141	141
2013	195	183	195
2014	270	236	270
2015	375	305	375
2016	519	390	487
2017	720	496	631
2018	998	626	812
2019	1,384	782	1,040
2020	1,918	964	1,322
2021	2,659	1,172	1,667
2022	3,686	1,395	2,082
2023	5,110	1,617	2,569
2024	3,847	1,801	3,122
2025	EXTINCTION	1,886	3,132
2026		1,526	1,757
2027		763	1,042
2028		65	634
2029		10	374
2030		10	183
2031		10	15
2032		10	10

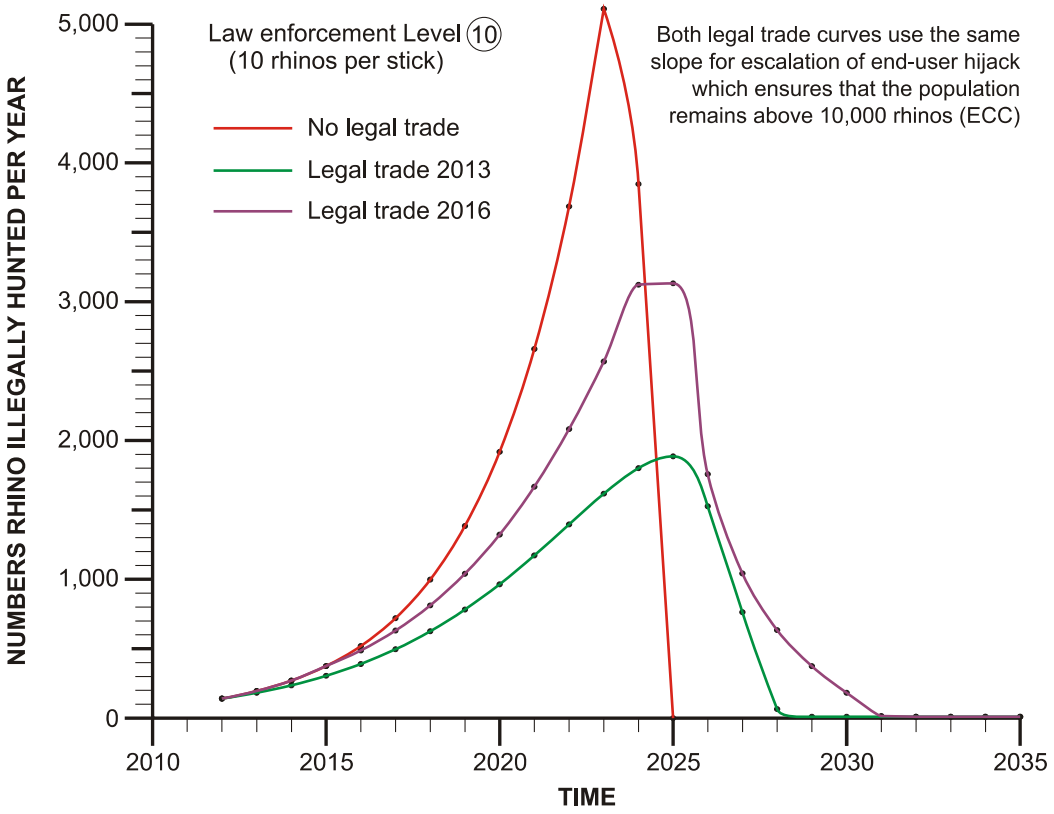
			Difference
TOTALS	**21,681**	**9,967**	**11,714**
LOSS US$	**1,734,480,000**	**797,360,000**	**937,120,000**
LOSS Rands	**13,008,600,000**	**5,980,200,000**	**7,028,400,000**

			Difference
TOTALS	**14,247**	**21,719**	**7,472**
LOSS US$m	**1,139,760,000**	**1,737,520,000**	**597,760,000**
LOSS R$m	**8,548,200,000**	**13,031,400,000**	**4,483,200,000**

LOSSES AT THE NATIONAL LEVEL

Scaling-up factor **1.67**	**US$**	**Rands**
No Legal Trade: loss of entire population 2012-2024	**2,890,800,000**	**21,681,000,000**
Legal trade 2013: loss reduction 2012-2024	**1,561,866,667**	**11,714,000,000**
Legal trade 2016: Cost resulting from delay in inception	**996,266,667**	**7,472,000,000**

Figure A3.7: Illegal hunting losses with no legal trade and with legal trade beginning in 2013 and in 2016



Legal trade beginning in 2013

(2) Under the framework of the simulation model, the legal trade reduces the number of rhinos killed illegally from 2013-2024 and ensures that the rhino population not only survives but also survives in substantial numbers, i.e. above 16,700 animals which is the assumed ecological carrying capacity for existing rhino populations in South Africa. This takes place under an expenditure on law enforcement which is not greatly different to that in place at the moment. The financial saving to the nation from this is some **US$1.6 billion** (R12 billion).

This is, of course, an incomplete financial statement since it does include the income which would have been generated from the sale of rhino horn from 2013-2024. Once the rhino population has reached its lowest value (10,000 animals around 2025) and begins to recover (**Fig.A3.6**, p28), the illegal trade is effectively finished and it takes only a few more years before all accounts are 'in the black'. The management of sales is a separate subject dealt with in **Appendix 4** (p32).

Legal trade beginning in 2016

(3) The cost of delaying the submission of a proposal to CITES for a legal trade in rhino horn from 2013 to 2016 is evaluated in **Table A3.3.** The same slope of escalation in number of end-users converting to legally obtained horn has been used (**Table A3.1**, p24). The additional cost arising from the continuing loss of rhino between 2013 and 2016 is **US$996 million** (R7.5 billion).

Appendix 4

Sales and Stocks of Rhino Horn

In this appendix, I examine some options for managing rhino horn stocks and the resulting income from the sale of a portion of these stocks. The subject is best discussed with reference to **Table A4.1** (page 35) which requires some interpretation. The table applies to the Kruger National Park rhino population which is assumed to be some 12,000 animals in 2012.

Population numbers (*column 2*)

The actual population numbers are taken from the curve for law enforcement Level 10 shown in **Fig.A3.6** (page 28). The population initially increases reaching a peak of 14,298 animals in 2018 and then declines to its lowest value of 10,132 animals in 2027 (this curve was selected to ensure that the population did not falling below the assumed ecological carrying capacity). It then begins to recover reaching an asymptote of some 17,000 animals in 2044.[24]

Illegal hunting (*column 3*)

The numbers hunted illegally reach a peak of 1,886 in 2025. Thereafter, the illegal trade is effectively finished (see first paragraph on page 27) and the annual loss of rhinos falls to 10 animals (set by the model).

Annual financial loss (*column 4*)

Valuing each of the animals illegally hunted at US$80,000 (set in the box at the top of the sheet), the losses caused by the illegal hunting are then calculated for each year. The annual loss reaches a peak of US$150 million in 2025. These losses do not actually appear in any books of account – which may be a valid criticism of present government accounting systems!

Amount of horn required to be sold to offset this financial loss (*column 5*)

The amount of horn which would be required to be sold annually to offset this loss is calculated assuming a price of US$10,000 (set in the box at the top of the sheet). The amount rises to 15 tonnes in 2025 (effectively the entire stock of horn in South Africa). Fortunately, there is no requirement to ensure that the amount from annual horn sales causes the ledger balance (*column 12*) to remain at all times 'in the black'.

Sources of horn (*columns 6-9*)

The numbers shown in these columns are the amounts which will be sold in the given year. Horn is available from natural mortality (*column 6*), from dehorning operations (*column 7*) and from existing stocks (*column 8*). I have not included the potential amount of horn from confiscations because this is automatically incorporated into existing stocks.

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24. In practice, the KNP population would be prevented from reaching this asymptote by an aggressive policy of sale of live animals – the income from which is not included in this table. The national population of rhino should increase at an even higher rate than predicted by the progress towards the asymptote shown in the table because the growth rate of the rhino population outside the park should be more than 6% per year.

The horn which will arise from natural mortality is calculated at a rate of 0.05 kg/rhino/year applied to the full population in *column 2* and it is assumed that 75% of this horn will be found (numbers set in the boxes at the top of the sheet). The amount is not large (~ 0.5 tonnes/year) and, to simplify calculations in the spreadsheet, it is assumed all of this horn will be sold in the year in which it is acquired. However, it could just as well be added to the total stock of horn.

Horn from dehorning operations is assumed to be an average of 0.8kg/rhino/year. This figure together with the percentage of the population which will be subjected to dehorning (40%) and the proportion of horn from dehorning which will be added to existing stocks of horn (10%) is set in the boxes at the top of the table.[25] The calculation of the total amount of horn arising from dehorning in any given year is done by applying the specified percentage to be dehorned (40%) to the total population and multiplying by 0.8kg/rhino/year. Of this amount, 10% is added to the stocks of horn and 90% appears in horn sales in the given year (*column 7*).

The amount of horn which will be taken from existing stocks and placed on sale in any given year is specified as a percentage of existing stocks at the top of the table (for the purposes of this exercise it has been set at 5% and the corresponding amount appears in *column 8*).

The total amount of horn appearing on sale in any given year is the sum of the amounts in *columns 6-8.* In the example chosen, this amount varies from 3.3-5.4 tonnes per year (*column 9*). From 2027 onwards the amount sold increases steadily by a small percentage.

Horn stock (*column 10)*

The starting stock of horn in 2012 has been obtained by assuming the total stock of horn in South Africa is 16 tonnes (set at the top of the table) and, of this, about 9.6 tonnes 'belongs' to KNP (using the same scaling-up factor of 1.67 which appears in **Table A3.3**, p30). Thereafter, the annual stock of horn is decreased by the 5% appearing in sales but increased by the 10% of the total amount of horn arising from dehorning. In the scenario depicted, this results in a slowly increasing stock over the full period (11.9 tonnes in 2044).

The strategy for management of this stockpile would rest with the RHSO and, by small variations in the percentage appearing on sales, the overall stock can be made to increase or decrease in the long term. It might be sound strategy to always maintain a strong 'capital base'.

Annual income from sales (*column 11)*

This is derived by applying the sale price (US$10,000/kg) to the horn amount in *column 9*. With this price being fixed over the duration of the spreadsheet, it results in an annual income varying from US$33-54 million. In practice, the RHSO would vary the price from sale to sale depending on the immediate objectives. Over the period 2013-2044, the cumulative gross income earned from sale of horn is US$1.4 billion (*column 13)*. The average income per rhino per year in this scenario is around US$3,100 (*column 14*). It can be raised to US$4,000 by increasing the dehorning percentage to 50% and increasing the percentage of total stocks placed on sale to 6%.

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25. This method has the advantage of allowing quick and dirty calculations over the entire spreadsheet. In practice, the proportions of animals dehorned annually may be varied from year to year to suit strategic aims of the Rhino Horn Selling Organisation (RHSO) and the stakeholders.

Ledger balance (*column 12)*

This is the reconciliation of the full value of rhino losses (*column 4*) with the gross income earned from horn sales (*column 11*). The figures in this column are the cumulative amount, i.e. what would be shown by any ordinary bank statement maintained over the period 2012-2044. I have pointed out that, under present accounting systems, the losses of rhino to illegal hunting do not 'appear in the books'. When they are made to appear in the books, it transpires under the given scenario that after an initial positive balance up to 2020 the ledger shows a massive deficit from 2021-2039. This is the period where the losses of the past are being paid for. The mortgage is acquitted in 2040 and from then onwards the 'true account' is 'in the black', ending with a credit of US$570 million in the year 2050.

It needs to be stressed that all of the income referred to so far in Appendix 4 is gross income. It does not take into account the costs of protecting the rhino. **Table A4.1** pertains to the Kruger National Park rhino population and I have been working on a law enforcement effort of 10 rhinos per stick (Level 10) in most of the preceding analysis, i.e. a cost of about US$6,000/rhino/year. The true amount allocated for rhino protection in Kruger is probably less than this and the best that can be said from the figures presented in this appendix is that the income per rhino would more or less meet the present protection costs.

A key variable in this analysis is the proportion of the total rhino population which is subject to a dehorning regime. The horn generated from dehorning is by far the largest component of the total horn presented for sale in **Table A4.1**. If all rhino were subject to dehorning, the gross annual income per rhino rises to over US$8,000 and would not only meet all protection costs but would leave SANParks with a substantial profit. To some extent this is academic: SANParks is unlikely to manage its white rhino for the maximum production of rhino horn.

If the legal trade in rhino horn works and reduces illegal hunting to a very low level as predicted from the scenarios presented in this study, the actual costs of rhino protection may be significantly reduced – in which case the returns from sale of horn become pure profit.

A final consideration is the price which rhino horn will fetch on the legal market. The analysis in **Table A4.1** has used a fixed price of US$10,000/kg throughout but manipulations of the price by the RHSO may result in considerably higher figures. At present, the black market price in South Africa is some US$10,000/kg but the amount which the end-user of rhino horn is paying may be between 4-6 times this amount. If the legal trade is successful in reducing the length of the supply chain which exists in the black market and horn can be delivered to the consumer more directly it is possible that a greater profit can be made at the 'farm gate'.

Table A4.1: Simulated sales and stock of rhino horn

Rhino value (horn only) US$	40,000		Starting stock of horn	16,000	kg
Rhino value (animal+horn) US$	80,000		% of existing stocks used per year	5	%
Horn price US$	10,000	/kg	Dehorning production	0.8	kg/rhino/year
Horn from natural mortality	0.05	kg/rhino/year	% of population dehorned/year	40	%
Finding factor	75	%	% of dehorned stock into vault each year	10	%

	KNP	LEGAL TRADE			SOURCES OF HORN				HORN	FINANCES			
Year	Rhino Pop	Rhino loss	US$ net loss	Horn required	Natural mortality	Dehorning	Stoc ks	TOTAL	STOCK kg	Income US$	Ledger balance	Cumulative Income	Income per rhino
2012	11,975	141	11,280,000	kg	kg	kg	kg	kg	9,581				
2013	12,702	183	14,640,000	1,464	476	3,048	479	4,004	9,610	40,038,469	25,398,469	40,038,469	3,152
2014	13,259	236	18,880,000	1,888	497	3,182	480	4,160	9,660	41,598,663	48,117,132	81,637,132	3,137
2015	13,689	305	24,400,000	2,440	513	3,285	483	4,282	9,724	42,816,846	66,533,979	124,453,979	3,128
2016	14,001	390	31,200,000	3,120	525	3,360	486	4,371	9,798	43,714,933	79,048,911	168,168,911	3,122
2017	14,205	496	39,680,000	3,968	533	3,409	490	4,432	9,876	44,317,945	83,686,856	212,486,856	3,120
2018	14,298	626	50,080,000	5,008	536	3,432	494	4,462	9,955	44,615,166	78,222,023	257,102,023	3,120
2019	14,278	782	62,560,000	6,256	535	3,427	498	4,460	10,028	44,598,716	60,260,738	301,700,738	3,124
2020	14,136	964	77,120,000	7,712	530	3,393	501	4,424	10,092	44,241,362	27,382,100	345,942,100	3,130
2021	13,861	1,172	93,760,000	9,376	520	3,327	505	4,351	10,142	43,510,259	-22,867,640	389,452,360	3,139
2022	13,441	1,395	111,600,000	11,160	504	3,226	507	4,237	10,172	42,369,680	-92,097,961	431,822,039	3,152
2023	12,875	1,617	129,360,000	12,936	483	3,090	509	4,081	10,179	40,814,305	-180,643,656	472,636,344	3,170
2024	12,172	1,801	144,080,000	14,408	456	2,921	509	3,887	10,157	38,866,671	-285,856,985	511,503,015	3,193
2025	11,368	1,886	150,880,000	15,088	426	2,728	508	3,662	10,104	36,624,542	-400,112,443	548,127,557	3,222
2026	10,549	1,526	122,080,000	12,208	396	2,532	505	3,433	10,020	34,325,260	-487,867,183	582,452,817	3,254
2027	10,132	763	61,040,000	6,104	380	2,432	501	3,313	9,925	33,126,476	-515,780,707	615,579,293	3,269
2028	10,470	65	5,200,000	520	393	2,513	496	3,402	9,847	34,016,557	-486,964,150	649,595,850	3,249
2029	11,435	10	800,000	80	429	2,744	492	3,666	9,812	36,655,717	-451,108,433	686,251,567	3,206
2030	12,306	10	800,000	80	461	2,953	491	3,906	9,814	39,055,262	-412,853,171	725,306,829	3,174
2031	13,043	10	800,000	80	489	3,130	491	4,110	9,845	41,101,251	-372,551,920	766,408,080	3,151
2032	13,675	10	800,000	80	513	3,282	492	4,287	9,900	42,870,565	-330,481,355	809,278,645	3,135
2033	14,221	10	800,000	80	533	3,413	495	4,441	9,973	44,413,093	-286,868,262	853,691,738	3,123
2034	14,703	10	800,000	80	551	3,529	499	4,579	10,063	45,787,572	-241,880,689	899,479,311	3,114
2035	15,130	10	800,000	80	567	3,631	503	4,702	10,165	47,017,220	-195,663,469	946,496,531	3,108
2036	15,503	10	800,000	80	581	3,721	508	4,810	10,277	48,103,321	-148,360,148	994,599,852	3,103
2037	15,829	10	800,000	80	594	3,799	514	4,906	10,396	49,063,907	-100,096,242	1,043,663,758	3,100
2038	16,106	10	800,000	80	604	3,865	520	4,989	10,521	49,892,240	-51,004,002	1,093,555,998	3,098
2039	16,336	10	800,000	80	613	3,921	526	5,059	10,648	50,592,705	-1,211,296	1,144,148,704	3,097
2040	16,524	10	800,000	80	620	3,966	532	5,118	10,777	51,178,110	49,166,814	1,195,326,814	3,097
2041	16,677	10	800,000	80	625	4,002	539	5,167	10,905	51,666,965	100,033,779	1,246,993,779	3,098
2042	16,800	10	800,000	80	630	4,032	545	5,207	11,032	52,072,415	151,306,194	1,299,066,194	3,100
2043	16,899	10	800,000	80	634	4,056	552	5,241	11,156	52,410,519	202,916,714	1,351,476,714	3,101
2044	16,979	10	800,000	80	637	4,075	558	5,269	11,277	52,694,710	254,811,423	1,404,171,423	3,104

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