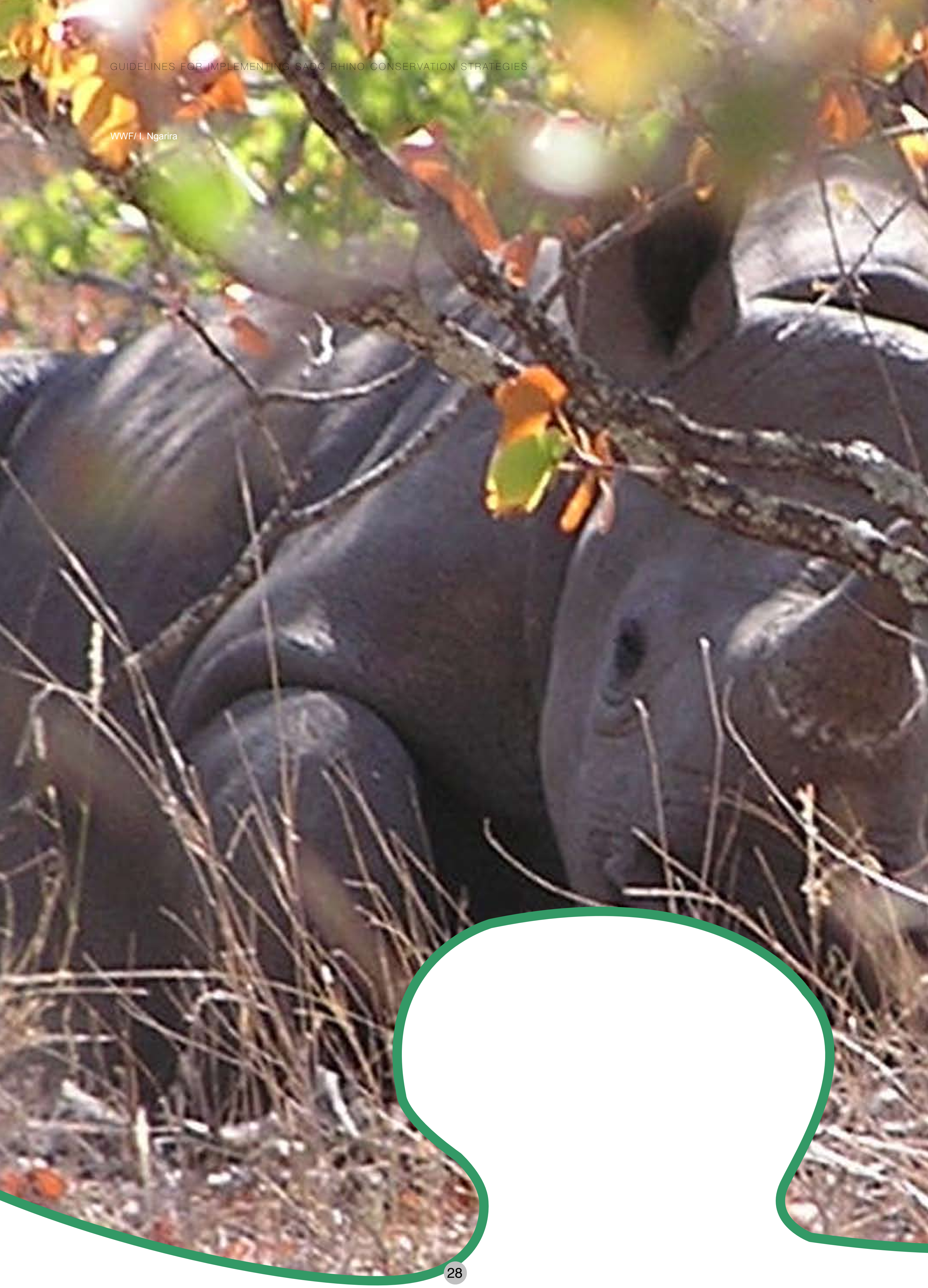

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ENSURING OPTIMAL BIOLOGICAL MANAGEMENT

SUMMARY OF GUIDELINES FOR: ENSURING OPTIMAL BIOLOGICAL MANAGEMENT

R. Emslie and R. du Toit

It is not sufficient only to protect rhinos in order to conserve them. The animals also need appropriate biological management, by which we mean measures to prevent overstocking, to prevent inbreeding and to meet other animal husbandry needs.

The rationale for biological management can be explained in terms of a ball game such as football. A game is won not only by a team defending against its opponents (i.e. protecting rhinos from poaching) but also by scoring goals (i.e. breeding more rhinos through sensible biological management). A rhino that is not born because of poor biological management is as much of a loss as a rhino that is slaughtered because of inadequate antipoaching efforts.

Sometimes the needs for rhino protection (which are easiest to achieve in small, highly-defended sanctuaries) conflict with the needs for maximizing the potential for population expansion. Holistic decision-making is required to balance the rewards in biological management of rhinos (i.e. encouraging population growth by spreading rhinos to new areas) against the risks (i.e. exposing the rhinos to poaching in less secure areas).

Quite small reductions in annual rates of rhino population growth (e.g. from 5% to 3%) can make a big difference to the number of rhinos that are present in a population in future. The situation is equivalent to interest rates on a bank account.

We use the concept of carrying capacity (which is not a precise and easily measurable level) to help us in achieving optimum biological management. To maintain maximum population growth rate, a rhino population has to be managed at a density that is significantly below the absolute (ecological) carrying capacity.

Estimating the capacity of an area's habitats to support rhinos requires the involvement of ecologists who have specific experience in this subject.

Because carrying capacity estimates are only approximate, adaptive management is required. This means that the managers of a rhino population have to be ready to react quickly to any indications of reduced breeding success, rather than assuming that theoretical estimates of carrying capacity are correct and therefore delaying biological management. Various indicators of rhino breeding performance have been developed and must be monitored in each population.

Even better than waiting for indicators of reduced breeding performance to trigger biological management, it is possible to implement a logical approach of harvesting rhinos steadily from an established population to keep it well below the area's carrying capacity. This approach maximizes the overall growth rate of the region's rhino populations (i.e. metapopulation growth).

There are significant financial costs, and some mortality risks, associated with rhino translocations. However, these are invariably outweighed by the benefits provided the translocation is undertaken with competent personnel and appropriate equipment, and provided the recipient area is adequately secure, understocked and comprised of suitable habitats.

There is rarely any justification for captive or semi-captive rhino breeding programmes within Africa, where free-ranging populations can be maintained more cost-effectively and with greater breeding success.

Professional monitoring of rhino populations is fundamental for their biological management as well as their security.

Rhino populations should generally be monitored using techniques that are based on the individual identification of some or all of the rhinos in each population. These techniques are only possible if the rhinos have identity markings (ear-notches), and also require population registers (databases) and specially trained field staff to undertake the identifications with a high degree of reliability.

Identity records of rhinos can be used either to simply keep account of all animals in a population (if all the rhinos are identifiable), or can be used as input data for statistical techniques to estimate the size of a population within which a proportion of the rhinos are identifiable.

Modern technology, especially radiotracking, has an increasing role to play in rhino monitoring but traditional bushcraft skills (spoor tracking, etc.) are still more important and this expertise must therefore be nurtured within rhino conservation agencies.

For large rhino populations in arid or semi-arid areas, regular aerial surveys based on specially-designed "block counts" can yield reliable indications of population trends.

Standardized reporting systems are required for the various rhino populations in order that demographic information can be subjected to regular professional review. This enables a direct comparison of the breeding performance that is achieved in the different areas, allows the overall metapopulation status to be confirmed, and assists in the identification of common rhino management issues that require national or regional attention.

4.1 Reproductive biology of black rhinos

Oestrus cycles have a mean of 35 days in the female black rhino, but true oestrus only occurs for one or two days during each cycle (Bertschinger,1994). Cycling can occur year-round, but conception is influenced by female nutritional status. Several populations have shown conception peaks at times of the year that correspond to improved rainfall conditions, and thus nutritional status of the female, in the months preceding conception (Adcock, 2000, 2003). The timing of these peaks varies across Africa with the seasonality (winter versus summer) of the annual rainfall pattern.

Black rhinos have a 15.4 month gestation period (Bertschinger, 1994) and the interval between calves can vary widely, depending on the age of the female and the nutritional conditions in the habitat. Under good habitat conditions and at densities below carrying capacity most females can produce several consecutive calves at 2 to 2.5 year intervals. Where conditions are less favourable, the average inter-calving interval exceeds 3.5 years. In many such cases a calf may be conceived but is lost as the pregnancy nears full term, or shortly after birth. Old females (28 years plus) may have difficulty regaining body condition after weaning each calf, and tend to have longer intervals between calves.

Mortality rates within the first year of life range from 8-14% on average in South Africa and Namibia. Mortality in sub-adults averages 2-4%, less than 2% in young and prime age adults (Adcock, 2003), and probably 4% or more in older rhinos. Male rhinos have a higher mortality rate than females, and fighting is the most common cause of their deaths. Most females die of old age.

More male calves are born than female calves, but male mortality rate is higher leading on average (although not always) to adult sex ratios that are biased towards females. Because of male territoriality limiting male numbers in all but the largest fenced areas, adult sex ratios tends to average 1.3 to 1.5 females per male in many populations. Larger populations have sex ratios of 1.1 to 1.2 females per male on average.

4.2 Reproductive biology of white rhinos

White rhinos are gregarious animals found in groups of up to 18 animals. Their reproductive behaviour involves stimulation from group interactions; breeding is therefore constrained if the species cannot form and maintain free-ranging groups, unlike black rhinos that do not require protracted social interactions in order to breed.

The oestrus cycle of a female white rhino is approximately 30 days in the wild, but may be longer in zoos (Owen-Smith, 1998). Cycling is year-round though bi-annual conception peaks have been noted. Body condition influences the rate of conception, with animals in poorer condition showing poorer reproductive performance. The gestation period is 16 months. Weaning occurs at about 12 months but the calf will stay with its mother for a further 12 to 24 months. Once the calf separates from its mother, it will temporarily join other groups and will eventually form a stable bond with one group. Age of sexual maturity in cows is similar to black rhinos, with first parturition at 6.5 years and older in wild white rhinos followed by subsequent calving at intervals of 2 to 6 years depending on nutrition and health of the cows.

White rhino bulls are territorial and serious fighting between bulls can occur. Subordinate bulls will be tolerated by territorial bulls if they are submissive. Calves are at risk of being killed by territorial bulls.

4.3 What is meant by biological management and why is it crucial?

Biological management is about managing rhino populations at a metapopulation rather than at an individual population level, to achieve demographic and genetic goals at an organisational, country, regional or subspecies level. In the case of black rhinos, conservationists seek to manage the animals (and sometimes also their habitats and other competing species) to achieve sustained metapopulation growth of at least 5% per annum; and where possible to promote longer term genetic viability (limiting inbreeding and minimising genetic drift).

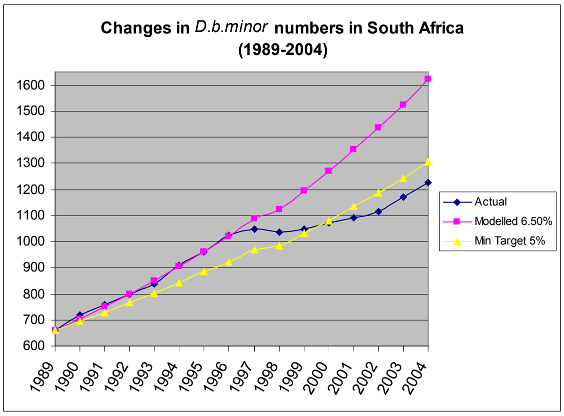
This 5% target is for the underlying (intrinsic) population growth, by which is meant the growth of a population after allowing for removals and introductions and man-induced deaths such as poaching. It therefore provides a more valid measure of the reproductive performance of a population than simple growth in numbers. This figure represents an achievable minimum target well below the estimated intrinsic maximum rate of increase of a population with typical age/sex structure, which would be around 9% annually; managers should certainly be striving to achieve growth rates of 6.5% plus. Rhino areas stocked well below habitat carrying capacity, and having female-biased sex ratios and low mortality rates, can sometimes achieve average population growth rates as high as 10-15% per year.

In populations approaching ecological carrying capacity (ECC), overall mortality can exceed 4% annually (involving mainly infants and sub-adults), while the females' average age at first calving and average inter-calving interval tend to increase. Average growth rates (referred to as "population performance") obviously decline as a result. Black rhino populations that have been allowed to approach or exceed estimated longer-term ECC (normally following a period of conservative low removals) have consistently exhibited a slowing of, and then a decline in, their growth rates to below 5% per annum as the available browse per rhino diminishes.

With the compounding effects from reduced reproduction in several populations, declines in metapopulation growth rates can quickly result in hundreds fewer black rhino in a metapopulation in a few years time. The example of the changing performance of the South African *D.b.minor* metapopulation over the period 1989-2004 (Figure 2) illustrates this. Estimated numbers of *D.b.minor* in South Africa grew rapidly from 1989-1996 at around 6.5% per year. However, due to conservative removals in some major donor populations, densities in some areas were allowed to approach or exceed estimated ecological carrying capacity. Numbers of competitive browsers have also increased substantially in some areas. Underlying performance in some populations became negative with the overall metapopulation performance being maintained only by rapid growth in other re-established populations. During the period 1996-2001, performance declined well below the minimum target levels (averaging only 2.0% per year). Over the last three years, the annual growth rate has improved to an estimated 4.2%, but is still below the target level of 5%.

Translating these percentages into rhino numbers, and comparing those numbers with the population sizes that should have been attained at a 5% annual growth rate, it becomes apparent that after being 101 rhinos above the target population size in 1996, it only took four years for numbers to start falling below the intended population size, and by 2004 the metapopulation was about 78 below target. If the earlier 6.5% metapopulation growth rate had been maintained through more aggressive biological management, then there would have been an estimated 397 more *D.b.minor* in 2004.

Figure 2: Changes in the estimated numbers of *D.b.minor* in South Africa from 1989-2004
Compared to modelled growth rates of 6.5% and 5% (allowing for removals/introductions from/to South Africa). Source: SADC RMG data (Adcock, 2005).



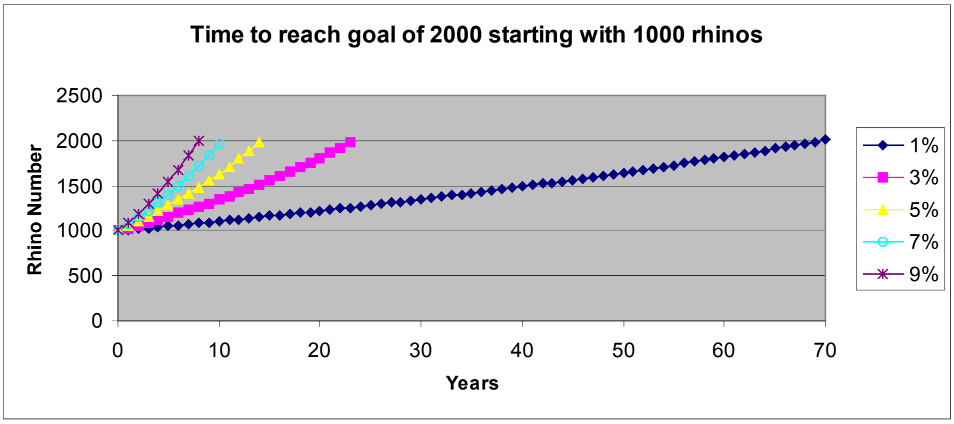
The fact that small differences in underlying growth rates can have a huge impact, over a few years, on rhino metapopulation sizes is illustrated further by Figure 3.

impacts. In the South African example, the loss to the metapopulation due to sub-optimum biological management far exceeded poaching losses which, however, invariably attract greater attention.

Managing rhino populations represents a form of investment management where one is seeking to get as many of the separate component populations (individual investments) in a metapopulation (portfolio) to increase at a rapid rate (generate good yields), so the overall metapopulation size (overall value of the investment portfolio) grows at a rapid rate. The underlying rhino population growth rate is therefore equivalent to the interest rate (percentage yield) on an investment. Just as in managing an equity (share/stock) portfolio, it is unlikely that every single rhino investment will perform well, but overall we should be striving to ensure that as many as possible of the rhino investments (populations), and hence overall rhino numbers in the metapopulation, continue to grow at a rapid rate.

Extending this analogy further, it is desirable to diversify and spread the investment risk by "putting eggs in different baskets". This can be done by harvesting rhinos at a significant rate from established rhino populations in order to establish various new populations, ideally under a variety of management models.

Figure 3: The time it would take for a metapopulation of 1,000 rhinos to reach a target of 2,000
given different annual growth rates of 1% (70 years), 3% (23 years), 5% (14 years), 7% (10 years) and 9% (8 years). After 25 years the net increase in rhino numbers at 1% would only be +282 compared with +7,263 at 9%.



The number of rhinos that are not born or which die prematurely due to overstocking must be regarded as seriously as poaching losses in terms of demographic

As an additional analogy, we can regard the biological management component in a rhino conservation strategy as being equivalent to attacking and scoring tries and goals in rugby and football. Without a strong defence (good anti-poaching and law enforcement) a football team will never win tournaments. Rhino protection and law enforcement therefore remains a critical component of any successful rhino conservation strategy. However, even the best defence will concede goals or tries from time to time. Similarly, the odd rhinos may sometimes be poached from well-run parks, but if numbers are breeding up rapidly (scoring goals) the impact of this poaching will be minimised. Just as the end result in a football or rugby match is simply the number of goals/points scored minus the number conceded, the number of rhinos in future will equal the net gain or loss due to reproductive growth rates of a population on the one hand (which can be enhanced/reduced by good/poor biological management) and mortality levels on the other hand (influenced by poaching levels and the quality of biological management).

It should, however, be appreciated that biological management is not just a simple case of managing rhino numbers. Social factors following removals in donor populations may have short-term negative effects. The age and sex structure of the donor population should be considered when choosing animals to remove. For example, the selective removal of young female rhinos over a long period may potentially skew the age (and sex) structure of a donor population, reducing its future performance. The build-up of populations of competing browsers or grazers, of other species, may also have a significant impact on rhino performance in some well-established populations. A reduction in densities of competitors may therefore improve rhino performance.

4.4 Concepts of “carrying capacity” and its estimation

The term “ecological carrying capacity” (ECC) refers to the number of a species that a defined area holds at a given time in a situation where the amount of available food/water resources is such that the numbers being born into a population are being cancelled out by the numbers dying; hence the population size remains fairly constant.

When a population of rhinos has been established in a new area with suitable habitat it is likely that if given sufficient protection, the population will continue to grow rapidly for a period. However, at some stage after densities increase, the amount of quality rhino food available per rhino will decrease to the extent that females take longer to put on sufficient condition to conceive and carry calves. This will result in inter-calving intervals lengthening, age at first calving increasing, and neonatal survival rates declining. Increased competition for food may also result in increased adult mortalities from fighting. Rhinos are believed to have a ramp-shaped production curve; at lower densities, population performance will largely be independent of density but density-dependent declines start becoming apparent once densities exceed about 75% of ECC and a graph of population growth then takes a downward turn towards zero.

The term “maximum productivity carrying capacity” (MPCC) refers to the maximum density of animals that a defined area can carry yet still be able to reproduce at the maximum rate possible.

In reality, there is no such thing as a fixed ECC or a fixed MPCCC because these capacities fluctuate in response to variables such as:

- variation in weather (droughts or frost events) from year to year;
- habitat dynamics (vegetation succession and growth);
- alien plant infestations;
- the impact of fire (can be positive or negative);
- browsing/grazing impacts on the habitats.

These complicating factors mean that carrying capacity estimation is neither straightforward nor precise. ECC estimates are at best approximate figures, estimated as the probable average for a period of a few years. Despite these limitations the concepts of ECC and MPCC are still useful management tools and are used to help decide on harvesting levels and to assess whether or not potential new areas are large enough for rhino introductions. Practically, accurate estimation of ECC in large unfenced areas is less important than for smaller fenced areas. Reasonable estimation of ECC for the latter becomes increasingly important in countries where there is a wider range of ECC's and where reserve sizes tend to be limited, such as in South Africa or Kenya.

All approaches to the estimation of black rhino carrying capacity require some ecological expertise (species identification, ability to assess relative amounts of available browse, soil nutrient status, etc.) and the person(s) doing an assessment should have knowledge of rhino densities and habitats in relevant ecosystems. Rangeland ecologists who do not have specific experience in rhino feeding ecology generally tend to over-estimate ECC and this can therefore create significant management problems or unrealistic expectations.

An approach towards the systematic, statistical estimation of carrying capacity of some black rhino habitats was initiated by the RMG and has been elaborated and investigated as a SADC RPRC task (Adcock, 2001, 2005; Dunham and du Toit, 2003). This quantitative approach requires ecological expertise and fieldwork effort to determine factors such as the soil nutrient status of an area, the amount and quality of palatable black rhino browse up to 2m above ground, the proportional contribution of the different habitats in the area, average annual rainfall and rainfall distribution through the year as well as the minimum July temperature. As a fundamental component of the model for estimating black rhino EEC, the methodology for quantifying available browse in specific habitats (Adcock, 2004) has been evaluated during a SADC RPRC trial (Adcock, 2005) and is being used as a habitat monitoring tool in some areas where resources permit the detailed fieldwork that is required.

In many situations when re-introduction sites have to be evaluated or rhino management needs have to be determined, the most pragmatic approach will be to get these areas assessed on a less quantitative basis, by ecologists who have knowledge of rhino densities in relevant ecosystems. If the carrying capacity can be estimated, with some confidence, in a "ballpark" range of 1 rhino per 5 km^2, 10 km^2, 15 km^2, 20 km^2, etc., then this estimation will suffice for most planning purposes in larger areas, especially since a process of adaptive management will be required to take account of changing habitat conditions. However, some form of vegetation monitoring/assessment may still be required, especially in fenced sanctuaries, as build-ups in densities of other competing species (impala, nyala, elephant and giraffe) or other factors (vegetation succession, impacts of fires, alien plant invasions) can substantially alter rhino ECC's (positively or negatively) over time.

Less work has been done on estimating white rhino ECC's, although estimates can also be made by experienced ecologists based on comparative densities in similar habitats.

As rhinos are long-lived, taking years to grow to their full size, and are relatively slow-breeders, they may overshoot carrying capacity before signs of density-dependent reductions in performance are recorded. Thus it is inadvisable to wait for signs of reduced performance (increased inter-calving intervals, increased neonatal and adult mortality rates) before taking action. The ideal is to pro-actively start removing rhinos before population performance starts to suffer, as is discussed further below.

4.5 Recommended harvesting-for-growth strategies

Following realization of the decline in breeding performance in a number of conservatively harvested populations in South Africa, increased attention has recently been given to improving biological management, and the issue was tackled as a specific task of the SADC RPRC (Emslie, 2001). This review of relevant scientific principles and of case studies of rhino breeding situations led to management recommendations that were endorsed by the AfRSG and SADC RMG.

The fundamental recommendation is that established black rhino populations that are reaching relatively high densities (in terms of the estimated ECC) should be managed productively and pro-actively by either keeping rhino numbers at or below 75% of ECC; or preferably, in larger populations, by annually translocating a set percentage (5-8%) of the population once densities exceed 50% of ECC. With set-percentage harvesting, the population should adjust its density and eventually stabilise at a level that can sustain that level of harvest. Thus if one removes 5% annually the population's density should adjust to the point that the regeneration rate of the population is 5% (although numbers remain stable as this reproduction is cancelled out by removing 5% of the animals). The corollary is that if one removes less than 5%, the population performance will in due course decline to below the target 5% level.

Advantages of set-percentage harvesting, compared with the strategy of harvesting to a level that maintains a population at an estimated level of 75% of ECC, are that the latter approach:

- is less influenced by the accuracy of ECC estimates;
- will automatically result in densities adjusting in response to fluctuations in ECC;
- yields more predictable and more constant annual removals each year, hence facilitating the planning for translocations and other forms of management.

For black rhinos, removals should be spread throughout an area rather than being concentrated in one section. However for the better-dispersing white rhinos, concentrating removals creates a low-density sink area into which surplus animals can move. This in turn simulates the natural regulatory process of dispersal, which is often prevented by a reserve fence.

Combining these harvesting concepts with the concept of spreading rhino “investments” (Section 4.3), it is apparent that surplus rhinos should be routinely translocated to: a.) reduce the densities of the more heavily stocked populations in an attempt to increase or maintain breeding performance; and b.) create new populations or to enhance existing re-established populations with good potential for growth.

Translocation is therefore a key facet of rhino biological management. In some countries the sale of surplus animals can help cover some of the costs of rhino conservation, management and monitoring. However, re-established populations can take some years to become established and to achieve optimum breeding rates, particularly if they have few founders. Hence offtakes have to be planned with due consideration as to whether the population is sufficiently well-established to yield “surplus” rhinos (and if so, how many) and which particular animals should be removed to maximize genetic variability of the rhino population in the source area as well as in the recipient area (see Section 4.9).

4.6 Social carrying capacity of males

The number of adult male black rhinos that a smaller fenced area can hold is limited by social factors. The log of average adult male black rhino home range size in an area has been found to be inversely proportional to the log of the black rhino carrying capacity of an area, even though individual rhino home range sizes vary greatly (Adcock, 2001). Thus in areas of low rhino carrying capacity, such as 0.01 rhino per km^2, (or 1 rhino per 100 km^2), the ranges of adult males average around 380 km^2. Areas that can carry 10 times more rhino (0.1 rhino per 10 km^2) tend to have ranges averaging 44 km^2; while areas that can carry 1 rhino per km^2 tend to have ranges averaging around 5 km^2. If an area is stocked with more adult males then it is likely that some may be killed by fighting. The fighting risks are particularly severe if bulls are brought in some time after other males have become established within the area.

In some populations chance demographics can result in a male bias. If not managed, these surplus males may end up not only killing each other but also killing breeding females, or injuring females to the extent that they lose condition and therefore breed poorly. Surplus males also use up valuable food resources that could be used more productively by breeding females. Options to deal with surplus males are limited. Setting up male-only populations in areas that are too small to hold a viable breeding population may be one option, but the way that this is done will need professional advice to avoid excessive intra-species fighting. At the 2004 CITES Conference of the Parties in Bangkok, a quota for limited sport hunting of five surplus black rhino males every year in South Africa, and the same quota for Nambia, were approved.

4.7 Costs of a "fortress mentality" that restricts rhino breeding

Many black rhino populations are today conserved in small fenced rhino sanctuaries or larger fenced rhino conservation areas (RCA's).

Fenced sanctuaries and rhino conservation areas (RCA's) have a number of advantages.

- Fencing reduces the potential area that rhinos may range over and hence allows law enforcement manpower and effort to be concentrated where the rhinos are. Without a fence, rhinos may move further out in different directions, with the result that the area which field rangers need to patrol can greatly increase, reducing the effective manpower density, and sometimes necessitating the use of skilled trackers. Supposing one has a circular reserve of 300 km^2 (park diameter of 19.5 km), protected by 30 field rangers. If the area is fenced, then the effective manpower density protecting the rhino would be 1/10 km^2. However, supposing the area is unfenced and some rhinos at the edge of the reserve were to move up to 10 km further out from the edge of the initial 300 km^2 area, this would increase the area available to rhinos to 1,228 km^2, but would effectively reduce the manpower density to only 1 man per 41 km^2.
- Fencing helps minimise conflict with neighbouring communities by keeping wild animals within conservation areas.
- In most sanctuaries or RCA's, the fencelines are checked every day and boundary road tracks are also checked for signs of spoor. Experience has shown that this has often provided a valuable early warning of illegal entry into rhino areas, allowing rapid deployment of rangers and specialised anti-poaching units.

However, fenced sanctuaries and RCA's also have some major disadvantages.

- Fenced areas can foster a "fortress-mentality" in managers, in which they focus on the ease of preventing poaching (a defensive game, as discussed in Section 4.3) rather than giving equal importance to achieving high reproductive rates (scoring goals). Without sound biological management of rhinos and other species in the enclosed sanctuary, and without an acceptance of some risks that are entailed in spreading rhinos to new areas (see Section 4.8), the managers of small fenced areas will inevitably get to a stage of sub-optimal reproductive performance of the rhinos once densities approach or exceed ecological carrying capacity.
- Fencing prevents dispersal of subadult white rhinos, in particular, as the natural mechanism for regulating population density of this species (black rhinos tend to disperse less readily than white rhinos do, but fencing is nonetheless problematic in this regard for this species as well). Even if biological management of an unfenced area is paralysed with indecision on the part of the authorities, or lack of resources to undertake translocations, some rhinos can still move out into new areas and the impacts of density build-ups are likely to be less severe than they would be in fenced sanctuaries.
- Because the distributions of other mammalian herbivores (e.g. nyala antelope) are also constrained by the fencing, and because some fence-breaking herbivores such as elephants may deliberately concentrate in a sanctuary to take advantage of water supplies and security, the densities of these species may exceed ecological carrying capacity with potentially disastrous impacts for both rhinos and the habitat. For example, in Ngulia rhino sanctuary in Tsavo West NP (Kenya), the build-up of elephants in the sanctuary and the failure to remove some or all of them has negatively affected the carrying capacity of the sanctuary for black rhinos (Brett and Adcock, 2002) and density-dependent reductions in rhino performance are apparent.
- The fencing entails significant expenditure for construction and maintenance, detracting from the operational budget for the area and also requiring a commitment of manpower and administrative effort that could be spent on other aspects of rhino conservation.

- Fencing can create a false sense of security; whereas the fences can be made cost-effective for the containment of rhinos, making them human-proof is not achievable without major expenditure (notwithstanding options for modern fence electrification systems).

4.8 Translocation risks versus potential gains

Rhino managers are often overly cautious about undertaking rhino translocations, particularly in situations where national or provincial rhino numbers are low and/or where poaching losses have been high, or where custodians or other stakeholders are opposing the removal of rhinos from an area in which they have a vested interest. Experience has shown that field managers faced with reduced performance in a population that is close to estimated ECC can become more hesitant to remove more animals, at the very time when removals should increase to return the population to productivity.

Certainly, it is important not to destabilize a re-introduced population by harvesting rhinos from it before it has reached a stage of definite genetic and demographic viability (assuming that there is potential for it to do so in that area). It is also important not to spread the available resources (manpower, expertise, equipment, etc.) too thinly by starting up new re-introduction projects before existing ones are adequately consolidated. However, it is equally important to translocate rhinos from the area if there are strong reasons to do so (e.g. overstocking, poaching losses, poor sex ratios) because the risks of mortality during the translocation are almost always justified in demographic terms. It is also important to avoid delaying translocations until the physical condition of the animals has declined significantly, because by that stage the animals will be more susceptible to translocation mortality risks; and in some cases habitat changes may have reduced the longer term potential for an area to hold rhinos.

Assuming that a competent team is undertaking the capture and translocation, the translocation mortality rates can be expected to vary from about 2%, as has been experienced in Zimbabwe in recent years, to about 5% as experienced in South Africa and Namibia (Adcock, 2005). The losses of rhinos at those rates can soon be fully compensated for by the improved rhino population growth rates in new area. If, for instance, there is the option of moving 20 rhinos from a donor population that is maintaining a sub-optimum growth rate (e.g. 2% per annum) because of overstocking, to a recipient area where they can maintain a moderate growth rate (e.g. 5% per annum), and being subject to a 10% translocation mortality rate (i.e. twice what might be expected from regional experience), then the following scenarios are possible.

- If 20 rhinos are moved, with 2 deaths during the translocation, there would be 18 remaining in the new population which (at a 5% annual growth rate) would increase over 10 years to 29.
- If the 20 rhinos are not moved, they would increase at 2% per annum over 10 years, to only 24.

A move of rhinos under these conditions would probably also allow the growth rate in the source area to improve due to the alleviation of density-dependent constraints, resulting in even more rhinos in the metapopulation. Conversely, leaving the rhinos would probably result in the growth rate decreasing below 2% as these constraints worsen.

4.9 Which specific rhinos should be translocated?

In most situations, it will be apparent that the most suitable female candidates for translocation will be those that are:

- unrelated (as far as is known) to others that would make up the founder group at a re-introduction site, in order to maximize genetic diversity;
- not with young, dependent calves at foot (for the above reason and also because young calves are more prone to translocation mortality risks, although under careful management those risks can be reduced to acceptable levels);
- capable of breeding (as far as is known);
- in fair physical condition, and not of

advanced age, so that they can withstand the stresses of translocation and release in an unfamiliar area.

Prime female candidates for translocation are young cows that are close to attaining the age of first conception or which are in the first trimester of their first pregnancy. Not only are such animals most likely to fit all the criteria above, but if the objective of the exercise is to reduce population size and growth rate in an overstocked source area, then the removal of females in this age class will have the greatest effect. However, care needs to be taken to avoid skewing the age structure of a donor population towards older animals by continuous selective removal of young females over a longer period.

For bulls, the situation is more complicated. The following questions arise.

- Genetically, is it better to remove sub-dominant bulls, or dominant bulls that have already contributed genetically to the next generation of the population within the source area?
- Behaviourally and demographically, would removing dominant bulls stimulate an undue level of intra-species fighting within the donor population as their potential replacements struggle for dominance?

The issue of genetic contributions will depend upon site-specific issues and in particular upon the overall size of the donor population, and whether or not any of the dominant males are founders within that population (see Section 5.1 for definition of "founder"). If the donor population is well-established (50 or more animals, with several generations) then it will be least disruptive to that population to harvest "subsidiary" or subadult males. This age class is the one in which natural dispersion is most likely to occur. If, however, it is clear that some males are heavily monopolizing breeding within a smaller donor population (at an extreme, breeding with their daughters) then consideration should be paid to moving them out, especially if they are being added to an area that includes founders from at least two different populations so there is minimal chance of them being related to other rhinos in the new population.

4.10 Captive or semi-captive breeding

In keeping with the strategic approach of "putting eggs in different baskets", it is desirable that a certain number of rhinos of each subspecies are maintained within *ex situ* (i.e. outside the region) captive breeding programmes. However, those programmes must be regionally or internationally coordinated ones that ensure metapopulation management amongst a number of zoos (such as the North American Species Survival Programme). Linkages with these international programmes and their member zoos can and should result in a flow of conservation funding and other support back to the areas from which rhinos are sourced.

There is very little rationale for captive or semi-captive rhino breeding programmes within the SADC region *(in situ)*, because the following problems arise.

- The browse of black rhinos is difficult if not impossible to replicate in artificial diets and captive black rhinos commonly develop various diet-related heath problems. It is believed that many of these problems are related to iron-overloading which occurs because of the dietary imbalances. Some captive breeding facilities in the region have run into these dietary problems despite attempts to include natural browse in the diets of their black rhinos; for instance, a rhino that died after some years in captivity at the Chipangali Wildlife Orphanage in Zimbabwe had the highest level of iron overloading that has ever been detected in the liver of a rhino.
- White rhinos do not breed readily in zoo conditions because of the importance of group behavioural stimulation in this species (see Section 4.2).
- The cost-effectiveness of captive breeding programmes is very low. Rhino population gains from these programmes are extremely poor compared to those from programmes that conserve free-ranging rhinos; although births are achieved, mortality rates are high, and expenditure per surviving rhino is many times what is typically spent on each rhino in non-captive conservation project.

- Captive programmes can divert funding and public attention from non-captive rhino conservation projects, to the detriment not only of those free-ranging rhinos but also of biodiversity conservation in general.

Semi-captive (or semi-wild) black rhino breeding projects (e.g. at Imire in Zimbabwe) have performed better than totally captive breeding projects, mainly because of the greater scope for natural browsing. The rate of breeding can be speeded up by separating calves from their mothers and hand-rearing them, so the mothers breed again with a shorter inter-calving interval than would occur if the calves were left with them. However, the overall cost-effectiveness of these projects remains low, especially once the costs and complications of rehabilitating the offspring into wild populations are taken into account.

It is sometimes argued that keeping some rhinos in captive or semi-captive facilities is important for community awareness and conservation education, especially for urban populations. However, these needs can be met with rhinos that are not important for breeding programmes (e.g. surplus males, or females that are known from monitoring records to be poor breeders or totally barren, or rhinos with debilitating and permanent injuries such as severe snare wounds).

4.11 Monitoring of rhinos

4.11.1 Why monitor rhinos?

The foremost reason for monitoring is to “audit” rhino populations and to check that none of their members, being valuable biological assets, are missing because of illegal offtakes or other demographic impacts. The knowledge that a rhino population is being kept under close demographic surveillance, so that any poaching will be detected, serves to deter would-be poachers including corrupt elements within that area’s protection/management force. The need to be able to undertake “auditing” fully justifies the costs and (relatively small) risks of immobilizing rhinos in order to cut ear notches as identification features.

A second major reason for rhino monitoring is because the adaptive management that is required to maximize metapopulation growth rates for rhinos is not possible without reasonably accurate annual population estimates, measures of demographic performance, and information on mortality patterns, behaviour and translocations.

The sharing and synthesis of this information at a national and regional level (for example, the routine annual black rhino status reporting and periodic analysis of data within the SADC RMG) serves to provide:

- measures of progress towards meeting metapopulation goals (in the form of underlying metapopulation growth rates, and the consequent estimates of how long it will take to reach target metapopulation sizes);
- estimates of population sizes and densities which can be used to derive recommended offtake levels (either using set-percentage harvesting or by keeping numbers at or below 75% of estimated ECC);
- data on the comparative performance of the different populations in a metapopulation, which encourages each park manager to put that park’s rhino population performance into context, and to consider how that population can help contribute to attain metapopulation goals;
- additional insights into factors affecting rhino population performance;
- an effective way to share lessons learned from both experience in the field and the results of research;
- a consolidated record of movements of rhinos within and in and out of a metapopulation.

4.11.2 Monitoring rhinos through individual identification

For all but very large areas (>2,500 km^2) and for very large populations (>500), rhino populations can and should be monitored using techniques that are based on the individual identification of some or all of the rhinos in each population.

Ideally, the rhino monitoring staff should regularly identify each and every rhino in a population. This is achievable in areas that are staffed by specialised rhino monitors, such as several Zimbabwean conservancies of 400-3,000 km^2, and exceeding 100 rhinos in some of these, with a confirmation sighting of each rhino every six months at least, and a ratio of approximately one monitor to 20 rhinos. In habitats with higher rhino densities, greater confusion can arise but the logistical demands in deploying monitors are reduced. Examples of such areas where populations have been reliably monitored through recognition of all (or virtually all) rhinos are Pilanesberg NP, Sam Knott/Andries Vosloo area of Great Fish River Reserve and many custodianship populations.

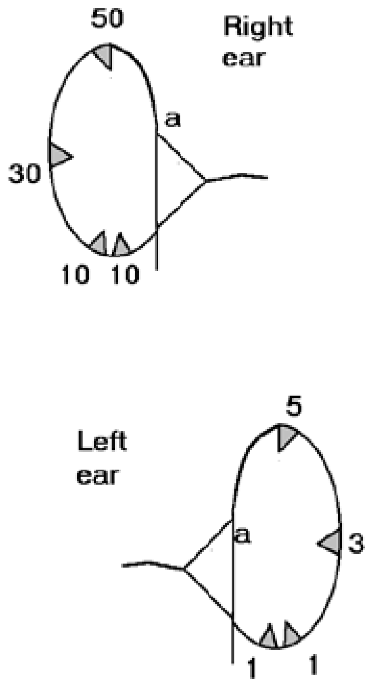
However, not all areas have dedicated rhino monitors or expert trackers and rhino monitoring may be carried out by field rangers as part of their general patrol work. In large , long-established populations a sizeable fraction of the population may not have easily distinguishable and easy-to-record features (ear notches and ear tears), and all patrol teams may not have digital cameras. In such cases all observers are not able to reliably identify all animals seen all of the time. Provided some animals have easy-to-record features (and can reliably be identified by ***all*** observers ***always***), and provided there are sufficient rhino sightings, it is still possible to accurately estimate population sizes with confidence levels using sighting/re-sighting (mark/recapture) statistical methods.

Once rhinos are individually identifiable, their details can be maintained in population databases which assist greatly in ensuring that information can be derived to meet the needs outlined in Section 4.11.1. Rhinos are identified as individuals primarily through natural ear tears and/or through the application of artificial ear notches.

A rhino ear can be demarcated into sectors within which combinations of notches can be cut (using both ears) so as to create a coding system for a large number of rhino identification (ID) numbers. Ear notch numbering systems differ from country to country and organisation to organisation. Some countries allocate specific numbers nationally, whereas others may simply be concerned that no two rhinos in the same population have the same ear-notches and if so will need to check when notched animals are being moved to another population to see if additional new notches are required to maintain a unique ID in the rhino's new area. Rhinos that do not have recorded ear patterns or other known features by which they are identifiable are known as "clean" animals.

Figure 4: Rhino earnotching system used in Zimbabwe, as an example.

By cutting notches that add up to the required ID number, any number up to 99 can be obtained. Punching a hole (about 10mm diameter) in the centre of the right ear would add 100, and a similar hole in the left ear would add 200, so a total of 598 ID numbers are achieved. Males and females, and black and white rhinos, are numbered in different series, so 1,196 animals of each species can be uniquely numbered. Cutting notches between the position marked "a" and the tip of the ear is not recommended as this notch is difficult to see when a rhino is facing the observer.



The aim is for every individual rhino to be given a unique identifier (ID) for life to enable population performance data to be derived (e.g. inter-calving intervals for each cow). The names and/or ID numbers of individual rhinos should not be changed, and ID numbers should not be re-used once an animal dies. In this way sightings of individual animals, database records, and sample collections, are less likely to become confused.

Quality control of sighting records is of paramount importance, because for monitoring information to be of any use it must be accurate. Those running field monitoring programmes must regularly check on the quality and reliability of the data being provided. Recognising and accrediting reliable observers assists with the quality control process. The use of compact digital cameras with 8-10x optical zoom capabilities has made it much easier for rhino monitors and other staff to reliably record sightings of rhinos. The submission of clear photographs showing identity features can be the basis on which to pay incentives to rhino monitors.

To ensure that rhino identifications are as reliable as possible and that sightings data are compiled in a systematic and comparable way, the AfRSG has developed a rhino ID training course (“toolbox”) which was revised with part-funding from the SADC RPRC (Adcock and Emslie, 2004). A number of training courses of field rangers using these course materials have been run within the SADC RPRC (e.g. Kamwi and Ngarira, 2004, Loutit et al., 2005).

However, it is important to note that successful completion of the training course does not necessarily qualify a trainee as a fully competent rhino monitor. The trainee, after the course, should certainly be able to record the key details (earnotches, sex, age class, etc.) of a rhino that is located in the field, but the course cannot ensure that the trainee will be able to locate the rhino in the first place; the tracking and bushcraft skills that are required to track and approach a wild rhino are beyond the training scope of this kind of short course. The recognition and retention of informally-acquired tracking and bushcraft skills within rhino management agencies is a key issue that is discussed in Section 7.1.

A system of monitoring black rhinos through flashlight photography at waterholes has been developed in Etosha National Park, Namibia (Cilliers, 1989) and would be applicable in other semi-arid areas that have a defined set of waterpoints rather than rivers or large waterbodies that the rhinos can drink at.

Footprint recognition systems, using tracings or photographs of rhino spoor, can be useful in certain situations but depend upon specialized training (and sometimes equipment and analytical software) and the various techniques have not yet proven to be cost-effective and practical for the regular monitoring of typical rhino populations. They may, however, have an application in deriving periodic mark-recapture population estimates (see Section 4.11.5).

4.11.3 Population master files and computerized databases

The monitoring of each population should allow the development of an accurate and up-to-date master file for that population, containing details of ear features (notches and tears) as well as other potential identifying features such as horn shapes and configurations, scars, broken tails, etc. It is recommended that separate files are kept for males and females as well as for records of animals which have died or been translocated to another reserve (i.e. those no longer present in the population). Where possible up-to-date photos and/or drawings should be used to record the details of features used to individually identify that animal.

When dealing with populations of 20 or more rhinos it is recommended that data be stored and managed using a computerized database. This database will contain key information and dates for individual rhinos (dates of births, calving records, details of ear-notching, mortalities, translocations) as well as all their sightings records. Ideally the database program should be able to interrogate the data and produce reports and answers to frequently asked questions. The SADC RPRC has developed a customized rhino database known as WILDb which is in use in several areas (Springett and Marshall, 2003)

4.11.4 Monitoring rhinos through radiotracking

The obvious potential of modern radiotracking technology to facilitate rhino monitoring has led to considerable experimentation (e.g. du Toit, 1996; du Toit and Mackie, 2001; Hofmeyr, 1998). Initially the focus of this experimentation was on neck collars as the means of attachment of the transmitters. However, two problems have been experienced with neck collars.

- The neck shape of rhinos pushes collars forward against the soft skin of the ear bases. Pressure lesions can develop in this region of the neck. No lesions of this type are known to have led to a rhino’s death or to serious long-term injuries but nonetheless it became apparent that alternative attachment options should be investigated, while still considering certain "animal-friendly" collar designs as an option.

- Through their wallowing habitats and movement through thickets, rhinos (especially bulls) tend to tear, abrade and rub off neck collars leading to greater rate of shedding of these collars than is typical in other species. Nonetheless, some collars have remained on lesion-free rhinos for long periods (e.g. 19 months).

The current trend of rhino radiotracking technology is towards the embedding of small transmitters in the horns of rhinos (Shrader and Beauchamp, 2001). Holes are drilled into the horn (generally the front one, but preferably the rear if it is long enough) into which the transmitter and its aerial are inserted and embedded within dental acrylic. These transmitters give typical ranges of 5-10 km for ground tracking and 10-25 km for aerial tracking, and generally transmit for 12-18 months (maximum about 24 months) before the horn growth and general wear result in their destruction (this period being considerably less than the potential battery life). A problem of "frequency drift" (i.e. the transmitters continuing to transmit, but not on their original frequencies) has often been experienced and requires further attention to resolve; some makes of receiver are considerably more useful than others in accommodating this problem.

The transmitters can include mortality sensors that change the frequency of the signal after a pre-determined period of immobility.

The costs of implanting transmitters are not normally justified except in certain situations when the technology is clearly cost-effective, such as:

- situations of active poaching activity;
- situations where post-release monitoring of translocated rhinos is required, particularly in large areas where it is difficult to monitor the rhinos through other means until they settle down into home ranges;
- situations where there is insufficient monitoring capacity to ensure regular sightings through spoor tracking and recognition of identity features (however, if radiotracking is relied upon in such situations, care must be taken not to develop over-reliance and complacency on the part of the monitors who may tend towards vehicle use and cursory confirmation of signals rather than visual checks).

Transponders are often confused with radio transmitters but are a different technology, being based on the activation of an implanted microchip by an external device (equivalent to a bar-code reader). These microchips are very useful for short-range confirmation of the identities of rhinos or horns, and should be routinely embedded when rhinos are immobilized for whatever reason, but do not have sufficient ranges for the monitoring of free-range rhinos. Hopefully, this technology will improve to the point that it does assist with longer-range monitoring, but immediate developments in this field will probably be linked to cellphone systems and will therefore depend upon cellphone reception being achieved within the rhino area.

4.11.5 Mark-recapture population estimation

Provided:

- rhino sightings have been collected throughout a reserve over a period of time, and
- equal attention has been paid to monitoring both identifiable and "clean" rhinos, and
- there are enough sightings of adults and independent sub-adult rhinos (ideally with the number of sightings being at least double the estimated total number of rhinos in these age classes),

then the RHINO Bayesian Mark-Recapture software package (which was extensively revised and re-written as Version 2.0, primarily with funding from the SADC RPRC) can be used to analyse the sighting: resighting records in order to produce accurate population estimates with confidence levels (Emslie, 2004).

RHINO is designed for use in populations where not all animals are individually identifiable (i.e. where a significant number of rhinos are "clean") and where monitoring data are collected primarily by anti-poaching patrols and other staff on an ongoing ad-hoc basis, rather than by specialised teams of rhino monitors. Additional knowledge that might be derived (about known deaths, introductions and removals in a population and where known calves have become independent of their mothers) is incorporated into the estimation process, which deals with some violations of classical mark-recapture assumptions. Population estimates with confidence levels can be produced at both a whole park and sub-park area level. The software can also help users assess the likely cost: benefit ratio in expending greater effort on collecting more sightings data and/or ear-notching more rhinos in order to improve the precision of the population estimate.

For some less intensively monitored populations, sightings data will not be accumulated on the regular basis that is required to run the RHINO program. In these situations, provided a significant proportion of the population has ear notches or other recordable distinguishing features, then periodic discrete surveys (“audits”) of a rhino population can be used to generate population estimates, using other (and sometimes more basic) methods of mark-recapture population estimation. Such estimates may have a lower degree of accuracy and precision than those that would be derived through the more continuous monitoring that is entailed for the RHINO program, but will nonetheless be useful. This use of periodic ground surveys may be relevant where there are insufficient rangers trained in rhino identifications to accumulate sufficient, reliable sightings data and specialist rhino monitors have to be brought in from other areas to conduct the surveys.

In Hluhluwe-iMfolozi Park, while ground-based rhino ID monitoring and RHINO population estimation are used to estimate black rhino numbers, there are simply too many white rhinos (around 1,900) for such methods to be used to estimate white rhino numbers as well. As a result, ground-based “distance sampling” is undertaken along cut-line transects (or from points in the wilderness area of the park) and is used to produce white rhino population estimates with confidence levels. However, this approach requires a large number of rhino sightings and has limited applicability elsewhere in the region.

4.11.6 Aerial surveys of rhinos

In very large rhino parks such as Etosha NP and Kruger NP it may not be logistically feasible to monitor rhino numbers using ID-based methods. Aerial surveys are a more practical option for these areas. However, standard aerial transect counting yields estimates of rhino population sizes that are well below the actual population sizes, and are highly variable, because of the difficulty of counting the rhinos in their typical habitats. This is particularly true for black rhinos despite their large body size, because these animals are often solitary, are widely dispersed, live in dense thickets, are camouflaged by dust or mud and are immobile during the middle hours of the day.

Instead of flying transects (straight lines) over a large area, a more effective way to count rhinos is to search small blocks (each of 10-25 km^2) within the area, using a small aircraft that can fly very slowly and turn tightly. By circling thickets, watercourses, etc., the pilot can ensure that these likely rhino refuges are thoroughly searched and rhinos are disturbed within them, making them more visible. Each block count constitutes a sample of rhino density and makes it possible to calculate the area’s overall rhino density within confidence limits, and with far greater accuracy than a transect survey because the undercounting bias is minimized.

In Kruger NP, white rhino numbers are estimated using aerial counts with distance sampling, allocating the rhinos that are seen to different distance bands from the aircraft and deriving a visibility correction factor for the counts by comparing the numbers that are seen in the closest band to the decreasing numbers seen in the further bands. Although an undercounting bias is still inevitable (because the factors outlined at the beginning of this section still apply), repeated surveys of this type can gradually built a fairly reliable indication of the population trend.

Photography during helicopter surveys has been successfully used to monitor both black and white rhinos in some parks although this is expensive.

4.11.7 Standardized reporting and demographic analyses

Annual reporting on the status of individual rhino populations using a standardised format, and evaluation of the results obtained collectively from one or more country, are fundamental means of meeting the requirements for monitoring and adaptive management as outlined in Section 4.11.1.

Status reporting needs to be coordinated centrally within a country, ideally by the National Rhino Coordinator (and in the case of the SADC RMG by the Chair), with responsibility for ensuring that appropriate status reports are solicited and received from each target rhino population. The coordinator also needs to ensure that the reports are analysed, ideally every two years, to determine population performance and to provide management recommendations. Subsequent evaluations will draw on the results of previous years to provide more robust estimates of population performance and longer-term trends. A specialist consultant may be selected for this purpose. This standardised interpretation allows for a range of populations under different management regimes to be objectively compared and unbiased recommendations to be made, within a confidential report (e.g. Adcock, 2005) that is returned to each of the agencies that contributed information on these populations.

Ideally a regional approach should be taken where a number of countries cooperate by submitting status reports to a single focal person or organisation for analysis. This allows for a broader evaluation of performance and improved opportunities for identifying problem areas and finding solutions. This approach, as taken by the SADC Rhino Management Group (RMG), has involved reports from South Africa and Namibia, and more recently from Zimbabwe. Priority in RMG reporting has so far been given to the two black rhino subspecies within the region, but the reporting could be extended to the southern white rhino if considered necessary.

The individual park status reports used in the SADC RMG region include the following sections.

- Population estimation.
- Sex and age structure.
- Female breeding performance.
- Mortalities.
- Introductions.
- Translocations.
- Behaviour.
- Security.
- Neighbour programmes.
- Research.
- Reports and publications.
- General.

Different status report formats are used for:

- state protected areas where each individual rhino is known (usually very small populations);
- state areas where this is not possible (large populations);
- private landowners.

This is because the type of information collected will vary according to the intensity and type of monitoring, but the use of standardised criteria allows for objective comparison.

4.11.8 Population performance indicators

A number of key indicators are used to determine population performance and to understand the underlying factors involved in populations performing below or above the internationally-accepted minimum annual underlying growth rate of 5 % for rhinos. Due to variable calving rates from year to year (in part a function of birth lags) population estimates are normally analysed over longer periods of three or preferably five years when estimating overall growth rates. The following demographic indicators have emerged from regional reviews.

Overall annual population growth rates

- >7.5% indicates good to excellent performance
- 5-7.5% indicates moderate to good performance
- 2.5-4.9% indicates poor to moderate performance
- <2.5% indicates poor to very poor performance (population may even be declining).

The calculation of growth rates must exclude translocations in or out. Managers of any populations performing at or below the minimum target level of 5% will need to look closely at the various performance indicators (as given below) for their populations to try to understand the reasons for their poor performance.

In small populations, percentage growth rates are less meaningful as a change in population size of just one rhino may have a big influence on the estimated growth rate. Underlying growth rates are not independent of sex ratio and for populations with a greater proportion of females growth rates should be higher. There are methods for correcting growth rate estimates for differences in sex ratio, and it is often important to do so in order to achieve a more objective assessment of underlying performance in response to habitat and other environmental and population density factors. Being equivalent to compound interest rather than simple interest, the annual population growth rate that is calculated for a population over a period of several years needs to be based on the correct formula, which it often is not (leading to inflated estimates).

Observed inter-calving intervals (ICI)

The average period between giving birth provides one of the best indicators of population performance. This measure is also largely independent of sex ratio. The measure is determined by observing the calving frequency of known females and averaging these values.

- >3.5 years for ICI indicates poor to very poor fecundity.
- 3.1-3.5 years for ICI indicates moderately poor to poor fecundity.
- 2.5-3.0 years for ICI indicates good to moderate fecundity.
- <2.5 years for ICI indicates good to excellent fecundity.

In some cases the actual inter-calving interval may be overestimated if a calf has been born and died and this was not detected; the indicator must be based on surviving calves.

Average percentage of adult females calving per year

This is a similar measure of performance to ICI. The main difference between average observed ICI and the percentage of females with calves under one year is that the latter measure includes those females that have not calved.

- < 29 % with calves under one year indicates poor to very poor fecundity.
- 29-33 % with calves under one year indicates poor to moderately poor fecundity.
- 33-40 % with calves under one year indicates moderate to good fecundity.
- >40% with calves under one year indicates good to excellent fecundity.

A value of 50 % is approximately equivalent to an inter-calving interval of 2 years, 33 % to 3 years and 25 % to 4 years. The average percentage of females calving per year should exceed 33%. A similar measure is to add up the number of calves born over a period and express this as a ratio compared to the number of adult female years for the same period. This value can then be converted to give an estimate of the percentage of adult females with calves born per year.

Average age at first calving

This is another useful indicator of breeding performance which can be used where the rhinos are individually known and frequently sighted. Females in rapidly growing populations may have their first calves as young as 6.5 years but in populations with poor performance age at first calving may lengthen to over 7.5 years.

Annual mortality rates

Very intensive monitoring is required to detect mortalities; in reality it is often very difficult to detect all calf mortalities, especially in large populations. However, the average annual mortality rate measured over a number of years is a good indicator, with 4% or less per year being considered as desirably low.

Early carcass detection and detailed post-mortems are essential if the causes of deaths are to be determined. Ideally based on a long-term data set, these records can provide very valuable insight into the causes of under-performance. Analysis of data from the RMG status reports over the period 1989-1998 indicated that man-induced deaths comprised 38% of the total (of which poaching accounted for 26%, and capture and translocation 11%); while of the natural mortalities, the major causes were reported to be fighting (26%), accidents (8%) and interactions with other species such as elephants (6%). The extent of mortalities due to poaching, inter-specific aggression and poor condition related to habitat conditions are particularly important to establish.

Nutritional problems are often the underlying cause of deaths that are ascribed to other factors; for instance “fighting” may be given as the cause of death when a rhino that is malnourished is injured by another and dies of injuries that would not be life-threatening to a rhino that is in good condition. This means that a significant number of the mortalities ascribed to other natural causes in the RMG reports (and also some of the translocation mortalities) are likely to be associated with problems such as overstocking and habitat constraints. National Rhino Coordinators should be very careful to consider possible nutritional factors when dealing with rhino mortality reports.