Int. Zoo Yb. (2006) **40:** 118–129

An integrated management strategy for the conservation of Eastern black rhinoceros *Diceros bicornis michaeli* in Kenya

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At time of writing Kenya holds *c.* 84% of the remaining *in situ* population of Critically Endangered Eastern black rhinoceros *Diceros bicornis michaeli.* The Kenyan 5 year Black Rhino Conservation and Management Strategy has given highest priority to the biological management of the subspecies in order to help achieve and maintain rapid metapopulation growth to increase rhinoceros numbers. Specific training and capacity building in monitoring of rhinoceros, from collection of field data to status reporting, have been implemented. Procedures to assess ecological carrying capacity for Eastern black rhinoceros habitat have been developed to help establish new viable populations and to optimize the management of existing sanctuaries, some of which face loss of suitable habitat owing to competition for resources between rhinoceros and other browsers. The management objective is to maintain rhinoceros populations below the ecological carrying capacity of a reserve in order to increase reproduction in 'donor' populations as well as the translocation of animals to create new populations with the potential for rapid growth. The conservation value of establishing site-level support relationships is also discussed. Kenya, for the first time since the 1970s, achieved a growth rate of $>5\%$ over the period 2004 and 2005 (the national goal is to increase numbers by at least 5%).

Key-words: biological management, capacity building, eastern black rhinoceros, ecological carrying capacity (ECC), population estimation, rhinoceros monitoring, status reporting

In 1970 the Eastern black rhinoceros *Diceros bicornis michaeli* population in Kenya was *c.* 20 000 but by the late 1980s this population numbered <400 animals (Foose *et al.,* 1992; Anon., 1993; Emslie & Brooks, 1999; Brooks, 2002; Mulama & Okita-Ouma, 2004) (Fig. 1). At the end of 2003 the *c.* 450 Eastern black rhinoceros in Kenya (*c.* 84% of the total *in situ* population) are spread across 14 sanctuaries, reserves and national parks, with habitats ranging from dense forest to semi-arid scrubland (Fig. 2; Plate 1). The Eastern black rhinoceros is considered Critically Endangered by IUCN (2004). This drastic decline was initially the result of culling in order to clear land for agriculture and was exacerbated by intense poaching, which occurred both within and outside the national parks and reserves. In 1984, in response to this rapid decline, Kenya implemented a strategy aimed at restoring the rhinoceros population. The strategy included the establishment of sanctuaries, collaboration between the Kenya Wildlife Service (KWS) and the private and community sectors, heightened protection through increased law enforcement, improved staff densities and capacities, revision of staff remuneration and drastic changes to the management of national parks.

This strategy halted the decline of the rhinoceros population in Kenya and since 1987 numbers have increased, albeit slowly, at an average annual growth rate of $<5\%$. However, if it had been possible to achieve even the AfRSG minimum

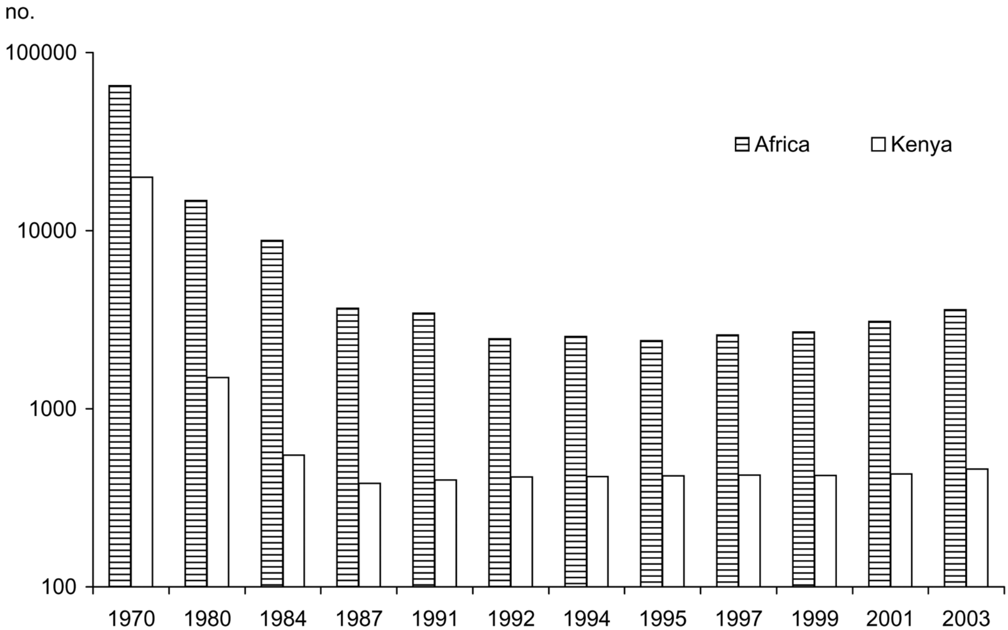

Fig. 1. Eastern black rhinoceros *Diceros bicornis michaeli* trend across Africa and in Kenya 1970–2003, in a logarithmic scale, showing the sharp decline and slow recovery. Data from Anon. (1993), Foose *et al.* (1992), Emslie & Brooks (1999), Brooks (2002) and Mulama & Okita-Ouma (2004).

acceptable (Emslie & Brooks, 1999) metapopulation growth rate of 5% per annum the population could have still grown significantly (Fig. 3). The value of 5% was chosen as the minimum acceptable growth rate as it is only just over half of r-max (9%) and should be attainable. In practice, one would hope to achieve higher rates of increase (6·5–9%). Given an expanding population with a young age structure in good habitat, one can temporarily achieve even higher rates of growth (10%+). As it is, even at the 5% rate it would take 30 years to achieve the target population level of 2000 animals; a level that could be achieved in 15 years if annual metapopulation growth rate could increase to 9% (i.e. near the biological maximum growth rate for non-sex-biased black rhinoceros populations). Large, rapidly breeding healthy populations not only provide the best possible insurance against future poaching losses but also preserve genetic diversity, or at least minimize loss of heterozygosity, by ensuring maximum rate of gene transfer to future generations (Gilpin & Soulé, 1986). In recognition of the importance of striving to maintain rapid growth to retain genetic diversity, Kenya's current Black Rhino Conservation and Management Strategy places greater emphasis on improving metapopulation performance through effective biological management (Anon., 2003) (Fig. 4). The strategy advocates managing for metapopulation growth of at least 5% per annum and preferably higher. To achieve this, specific capacity and procedural mechanisms were urgently required in: (1) field monitoring of rhinoceros, data collection, analysis and reporting, (2) production of standardized annual status reports that assess the numbers, performance and population dynamics of Eastern black rhinoceros populations in Kenya in order to aid biological-management decision making and (3) assessment of habitat conditions and ecological carrying capacities in fenced sanctuaries, allowing the management of habitats by adjusting rhinoceros and other browser population densities, and fire regime where relevant, and assisting in development of new viable populations. Several Kenyan sanctuaries have experienced or are experiencing high densities of rhinoceros and competing browsers, or very high/low fire frequencies, and there is a risk of the long-term productivity of the habitat being negatively affected.

MONITORING FOR MANAGEMENT

In order to monitor rhinoceros populations, Kenya has implemented a standardized programme of patrols to obtain information on rhinoceros sightings. Rhinoceros are identified individually and registers of the features of individual animals are maintained. Where needed, recordings are also made of sightings of 'clean' rhinoceros (i.e. those that are not individually recognizable). These monitoring data are used to provide estimates of population size, age and sex structures, calving rates (i.e. ♀ breeding performance), mortality rates (by age and sex), and the distribution and movement of rhinoceros. This information is used to gauge the performance of each population and guide biological-management decision-making processes, such as introductions and removals, to realize the national conservation strategy of increasing the total rhinoceros population as rapidly as possible.

The individual identification of rhinoceros requires properly skilled and motivated observers, a system of strict control on data quality at observer and data-recording levels, and the support of the wider conservation-management structure.

DEVELOPING MONITORING CAPACITY

Training A formalized training programme for personnel can greatly

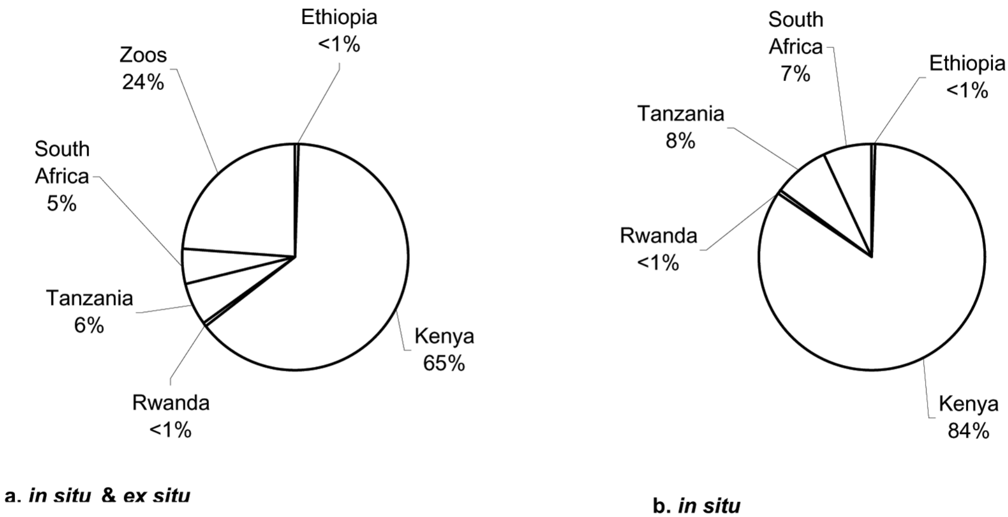

Fig. 2a. As at end of 2003 there were *c.* 540 and *c.* 170 Eastern black rhinoceros *in situ* and *ex situ,* respectively (AfRSG, 2004); b. Kenya is the stronghold of *D. b. michaeli,* with 458 rhinoceros in the population, as at end of 2003, mostly within sanctuaries, both in protected areas and on private land, and in a free-ranging population on county-council land. Tanzania has an estimated 42 Eastern black rhinoceros, mostly in free-ranging populations in unfenced protected areas and a few in one sanctuary. Rwanda and Ethiopia hold relict populations of one (in a protected area) and two to four (on community land) animals, respectively. As at 2003 South Africa had an estimated 36 *D. b. michaeli,* of predominantly Kenyan origin, out-of-range on private land.

accelerate the process of acquiring high standards of observational and data-collection skills. The project, funded through the UK government's Darwin Initiative, has implemented a sustainable field-staff training programme and, at the time of writing, 24 officers from national parks and sanctuaries have been trained as accredited rhinoceros-monitoring instructors in the continental-wide modular African Rhino Specialist Group (AfRSG) course. These field instructors are, in turn, training the *c.* 200 rangers in the field on an on-going basis. The process of testing and accrediting both trainers and trainees has helped institutionalize the process and provide formal recognition to those who gain accreditation.

A significant advantage of this approach is that staff can be trained where they are located, thus saving time and money and minimizing daily operational impact on the field teams. In addition, with continuous teaching of the modules it is possible to maintain consistency as well as deal with the inevitable staff turnover. Standardized data collection, including the use of the continental rhinoceros ageing and body-condition assessment systems, also means results can be compared between parks, including those in other range countries (Adcock & Emslie, 2004).

Tools and procedural mechanisms The Kenyan Rhino Programme has implemented data quality-control procedures in all its reserves to ensure that the data are collected on an on-going basis and are of the best possible quality. Field rangers have been trained to approach and observe rhinoceros, and accurately complete the standardized sighting forms (Fig. 5). This information is then checked by experienced accredited observers and the sightings are classified in accordance with the 'ID' master files, which are continually updated by the field officers.

The extensive sets of field data are stored and analysed using a comprehensive geographic information database management system (KIFARU). Standard-

Plate 1. An ear-notched and, thus, recognizable Eastern black rhinoceros *Diceros bicornis michaeli* **on the plain in Lake Nakuru National Park, Kenya.** *ZSL, London, UK.*

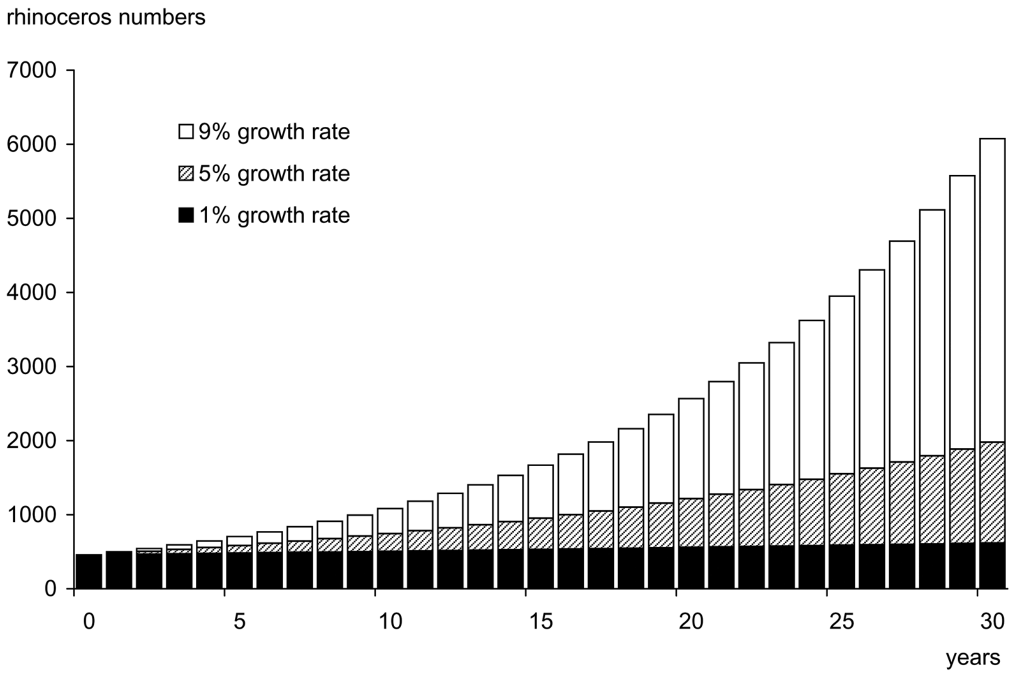

Fig. 3. Estimates of Eastern black rhinoceros populations after 1%, 5% and 9% growth rates. Since 1987 population numbers of the Eastern black rhinoceros have increased at an annual rate of 1% and, without biological management to improve population growth, it will take 170 years to reach the target population of 2000 rhinoceros. However, if population growth rates in Kenya increased to 5% per annum, this target population will be achieved in 30 years and at a rate of 9% the target population could be achieved 15 years earlier than this.

ized monthly reports provide key information, such as sighting frequencies of individual rhinoceros, patrol movements and the availability of manpower resources, which are used to optimize deployment of patrols and analyse population performance (Amin *et al.,* 2001).

Monitoring practicalities Tsavo East National Park, Kenya, is vast (*c.* 11 000 km^2) and the relatively low numbers of monitoring staff, coupled with international boundary-related problems, such as infiltration of firearms from neighbouring countries, have made the effective monitoring and security of the rhinoceros population in this area difficult.

Rhinoceros are rarely sighted during the day in the difficult terrain of the Chyulu-Hills National Park, or in the dense vegetation of Aberdare National Park and Ngulia Rhino Sanctuary in Tsavo West National Park, and this makes it difficult to estimate population size and structure accurately. However, these areas are important to the long-term conservation of rhinoceros in Kenya. Tsavo East and West National Parks are over 20 000 km^2 in total and have a very high capacity to assimilate rhinoceros from smaller, overstocked sanctuaries and parks. This area used to have over 6000 black rhinoceros before the poaching onslaught in the 1970s and 1980s.

The practical issues of achieving effective monitoring in these areas need to be addressed before such moves can take place. A number of initiatives are being developed and implemented. For example, the dry season full-moon night census is being improved using better planning and equipment to obtain more comprehensive

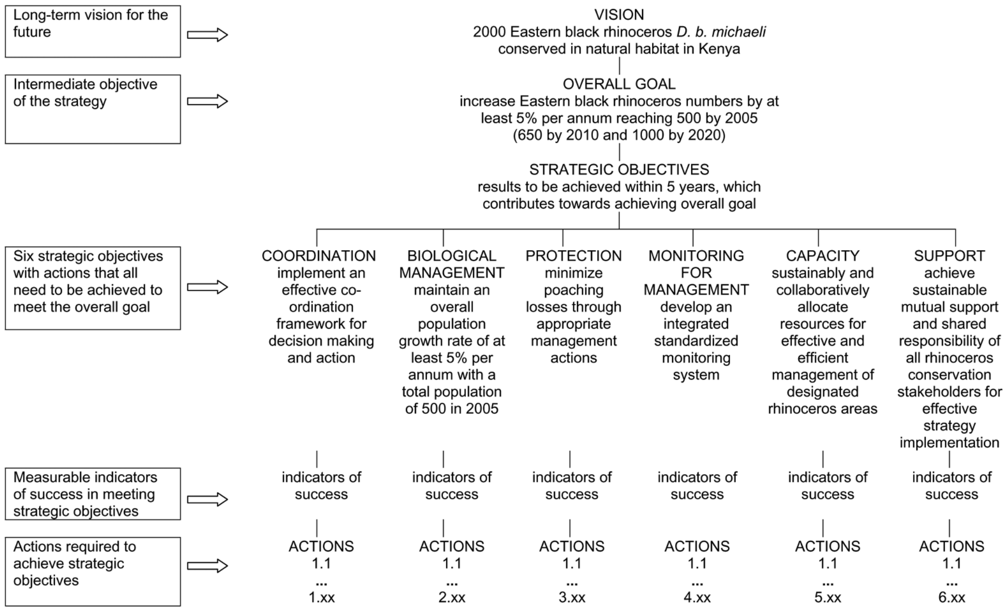

Fig. 4. The Conservation and Management Strategy for Eastern black rhinoceros sets six strategic objectives to achieve the national goal of increasing numbers of the subspecies to 1000 by 2020 and eventually achieving the target population of 2000 in natural habitat in Kenya (Anon., 2003).

population information in the Tsavo West National Park Ngulia Rhino Sanctuary. Systems to achieve more effective night-monitoring programmes are also being developed in Aberdare and Chyulu-Hills National Parks. A combination of direct and indirect methods for deriving indices of rhinoceros abundance, and relating these to indices of patrol and poaching activities, are also being considered to track population distributions and densities, and allocate law-enforcement efforts appropriately in order to protect these populations.

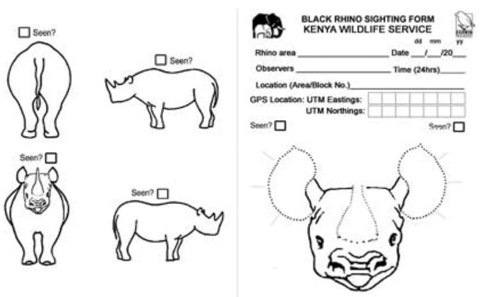

Fig. 5. One side of the standardized form used to record details of rhinoceros sightings.

Estimating population size A problem experienced in many Kenyan reserves is that an increasing number of animals that are not individually recognizable (i.e. clean). Young clean rhinoceros become unrecognizable once they leave their mothers. In the past, population estimates have only been based on identifiable animals, which provided a minimum index rather than an estimate of the true population size.

Reliable population-size estimates (within 90% of the true total) are required every year (or at least every 3 years) in order to assess how well a population is performing and to manage populations at the metapopulation level. This information, along with the ecological carrying capacity (ECC) estimate of each park and sanctuary, can assist programme man-

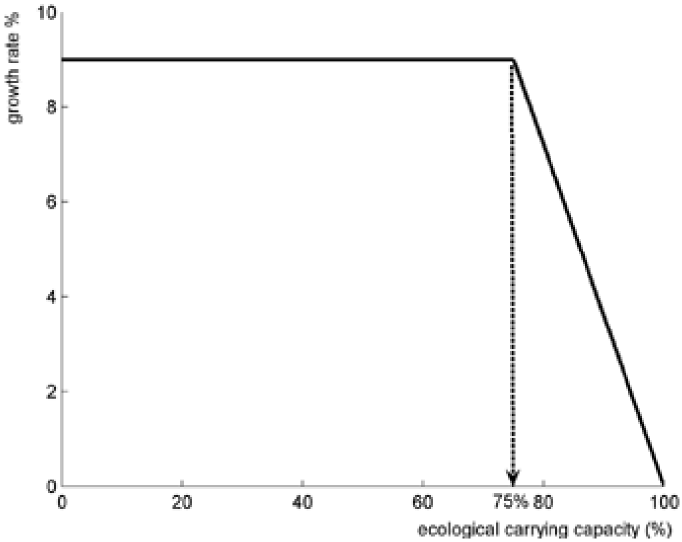

Fig. 6. K-selected species like rhinoceros are likely to have a plateau of nearly constant growth rate (density-independent phase), followed by a ramp of density-dependent decline once the maximum sustained yield level (*c.* 75% of carrying capacity) has been exceeded.

agers in making decisions that are necessary for achieving and sustaining high population growth rates.

The individual-identification-based monitoring method undertaken in all Kenyan reserves enables the use of mark–recapture methods for estimating population size. Field staff are being trained on a continual basis to ensure accurate recording of sightings of both identifiable and clean rhinoceros, with equal emphasis on each sighting. Rhino Programme scientists have also been trained to use the continental level RHINO Bayesian Mark–Recapture software tool (Emslie & Amin, 2003), which calculates population size using ongoing sighting data. To improve population estimates all rhinoceros immobilized for translocation or veterinary treatment are ear-notched for identification purposes as standard practice. When resources are available, specific ear-notching exercises are undertaken in areas with a high proportion of clean animals.

Annual status reporting National status reporting is a key component of implementing the conservation strategy. In the past metapopulation performance has been 'averaged out' in Kenya, thus performance issues within individual populations may have been overlooked. To promote optimal metapopulation performance it is necessary to look at the age and sex composition, calving rates of ♀♀, and causes and rates of mortality within each population. Reasons for sub-optimal performance can then be determined and solutions put in place.

A formal national-status reporting programme has been implemented. Kenya Wildlife Service scientists have been trained to analyse population performance data and synthesis of the national-status report. At time of writing, 26 officers from 13 reserves have also been trained in population data analysis and preparation of annual park-status reports. The training introduces the principles of status reporting, the concepts around metapopulation management and, in

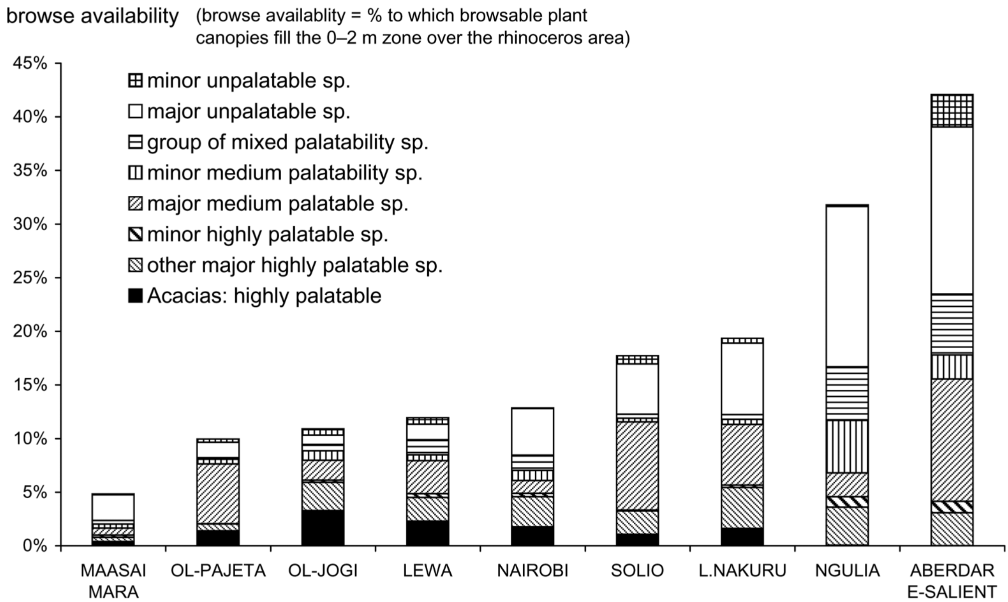

Fig. 7. Amounts of available browse in each of the nine main Kenyan black rhinoceros areas and the compositional breakdown of this browse by palatability class (i.e. the suitability of the browse component for black rhinoceros). Each class comprises several woody or forb species. Black rhinoceros browse is almost totally within a 0–2 m height range and the browse availability (BA) measure indicates the percentage to which this 2 m layer is filled by browsable plant canopies. BA was sampled by vegetation type and a weighted average BA was obtained accounting for the proportional area of each vegetation type within each rhinoceros sanctuary.

particular, the critical need to maintain rapid population growth rates (for demographic, strategic and genetic conservation reasons). Trainees are shown how to recognize the main causes of poor growth and how to interpret various performance indicators derived from their own ongoing ground-based monitoring of rhinoceros. The practical application of these indicators is also highlighted, as trainees are shown how monitoring assists with the decision-making process on sanctuary management and translocations.

The park-level status reports supply information on population size, age and sex structure, translocations and mortalities (including causes), as well as a number of standardized biological performance indicators (age at first calving, percentage ♀♀ calving, proportion of adult ♀♀ with calves, intervals between calving, mortality rates and net population growth rates) (Okita-Ouma, 2004).

The individual park reports are synthesized and analysed at a national level. The resultant national report interprets and contrasts the status, performance and population dynamics of all Eastern black rhinoceros populations in Kenya. The feedback from the national-status summary report is vital to programme managers and staff because it places the results of individual-reserve reports into a metapopulation context.

Without regular park-level status reporting and the production of interpreted national status report summaries, a problem may also remain undetected far longer. The first detailed status reports have shown clear density dependence in a number of populations stocked at or near ECC. The reports have indicated that a number of Kenyan rhinoceros populations could become donor populations. In addition, the *c.* 5% underlying population growth in Nairobi National Park following a period with an average 5% annual removal of rhinoceros has provided empirical support to the Set Percentage Harvesting approach advocated by the IUCN/SSC's AfRSG (Emslie, 2001).

ESTIMATING ECC OF SANCTUARIES AND PARKS

Achieving and maintaining a high metapopulation growth rate can only be realized if the areas maintaining rhinoceros are not overstocked relative to available habitat resources. This depends on an estimate of the ECC of each area.

It is not easy to measure ECC. Past estimates of Eastern black rhinoceros ECC have differed widely in the reports of different observers for the same area. In particular, non-experts have tended to overestimate substantially the ECC. Nevertheless, it is easy to conceptualize that a habitat at a given point in time must be able to support sustainably a limited number of any given herbivore species. This ECC is probably most closely defined as 'the maximum number of animals of a species (sustainably) supportable by the resources of a specified area' (Caughley, 1976; McCullough, 1992). Once the ECC is known, existing populations can be managed for maximum productivity and excess animals removed to enhance other populations or establish new populations as necessary. Estimation of ECC is also a necessary prerequisite for making decisions about the suitability of an area for establishing a new subpopulation. For large mammals, such as rhinoceros, evidence suggests that the maximum sustainable yield or MSY [commonly called maximum productivity carrying capacity (MPCC)] is *c.* 75% of estimated (long-term) ECC (Owen Smith, 1988; McCullough, 1992), although optimal stocking levels may be lower than this during drought years (Fig. 6).

Managing populations at or below 75% of ECC should minimize the risk of density-dependent effects negatively affecting populations (e.g. through reduced calving success and increased mortalities and social problems). By reducing densities of Eastern black rhinoceros and/or other browsers to below habitat carrying capacity, there is also a reduced risk of negatively affecting the long-term rhinoceros carrying capacities of the areas.

Performance in a number of Kenyan black rhinoceros populations may be poor because, in the past, inadequate attention was given to habitat conditions. Several reserves face loss of suitable habitat through high rhinoceros and competing browser densities.

Kenyan Eastern black rhinoceros ECC model The Kenyan Darwin Initiative project has developed an ECC model for the region. A similar model has been developed for the Southern African range states (Adcock, 2001). The estimation of ECC is multi-faceted. For a given amount of standing 'browse-plant biomass' the browse productivity (growth rate) and quality are primary determinants of black rhinoceros carrying capacity. Rainfall, soil quality and temperature influence these parameters on a broad scale and measures of these factors are also required. All nine well-established Kenyan rhinoceros sanctuaries were surveyed for browse availability and species composition (Fig. 7). About 100–150 detailed vegetation plots were assessed in each area and this information was combined with Landsat-7 satellite imagery data to give overall browse-availability and browse-suitability index maps. Auxiliary data on variables linked to Eastern black rhinoceros ECC were also compiled for the areas (game count data, soil and geology data, long-term rainfall and temperature records).

Monitoring habitats Habitat monitoring procedures have also been developed, and park ecologists and monitoring staff are trained in their use. This is important as ECC will change over time (in the medium to longer term) in response to habitat changes, which for Eastern black rhinoceros may be positive (increased browse availability of suitable plant species) or negative [favoured food plants declining or growing out of reach, unpalatable species increasing at the expense of more palatable species, increases in alien plants (e.g. *Lantana camara*), frequent fire, increased grass interference and/or an increase in browsing pressure following a build-up in numbers of competitive browsers (e.g. African elephants *Loxodonta africana,* Giraffe *Giraffa camelopardalis* and Cape buffalo *Syncerus caffer*)] (Plate 2). To be able to update estimates of ECC continually, therefore, requires an understanding of browser/browse dynamics, the nature of vegetation changes and their likely impact on ECC.

The estimates of ECC allow managers to take 75% of this figure as a ballpark estimate of the MSY level. Excess animals are then removed to maintain densities near the estimated threshold MSY level, thus maximizing rhinoceros productivity.

Monitoring the habitat resources as well as rhinoceros-population performance is useful in the light of changing vegetation in East African ecosystems and the influences of competing browsers. Large long-lived animals like rhinoceros may also overshoot carrying capacity before a potential problem in the population-performance indicators is identified.

SITE-LEVEL SUPPORT PARTNERSHIPS

Experience has demonstrated that even moderate additional external institution site-linked assistance can make a significant impact at the park operational level. KWS's collaboration with The Zoological Society of London (ZSL) and other partners to provide additional support for Ngulia Rhino Sanctuary, serves as an example of the value of such site-level initiatives. In addition to helping support infrastructural elements, such as water-system maintenance and vehicle provision, site-level links can assist the implementation and evaluation of the biological management tools and associated research areas. Securing out-of-region

Plate 2. Eastern black rhinoceros and African elephant *Loxodonta africana* **(competing browsers) observed during dry-season full-moon night census at Tsavo West National Park, Kenya.** *ZSL, London, UK.*

grants (e.g. the UK government's Darwin Initiative) is another important benefit that can arise from developing such partnerships which, in turn, benefit the wider national programme.

CONCLUSION

The successful development and implementation of the Kenyan Rhino Programme's integrated biological management and monitoring strategy across all rhinoceros parks and sanctuaries is key to providing decision makers with the information necessary to manage the national herd at the metapopulation level. Specific staff training in the field has meant that there is a consistency of data collection, which facilitates the ability to make accurate assessments of the status of the whole population. There has been the added benefit of gathering information on unrecognizable (clean) animals and including this in the population estimates for the region. Training has also been given in habitat assessment and data analysis, population data analysis and preparation of reports, so any problems with rhinoceros habitats, population status, performance or dynamics can be identified and acted on as quickly as possible. Ongoing evaluation and refinement of these tools and associated approaches provides the mechanism for optimizing Kenya's Eastern black rhinoceros annual growth rate as well as informing wider regional rhinoceros conservation efforts. The 2005 (end of year) national population estimate compiled at time of writing is 539 animals, which is an annual increase of over 5% (the national strategy goal is to increase numbers by at least 5%) (Okita-Ouma & Wandera, 2006). The end of 2004 national estimates also showed similar increase, for the first time since the 1970s.

ACKNOWLEDGEMENTS

The authors would like to highlight the support of UK government's Darwin Initiative, African Rhino Specialist Group (AfRSG), The Zoological Society of London, Kenya Wildlife Service Director Julius Kipng'etich, and staff of all Kenyan rhinoceros reserves for their continued commitment to rhinoceros conservation.

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Manuscript submitted 13 July 2005; accepted 13 February 2006; 9 May 2006