1.4 SANP Conservation Plan for the Black Rhino (Outdated Draft)

Species Conservation Plan: South African National Parks

Black Rhinoceros (*Diceros bicornis*)

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Introduction

The black rhinoceros *Diceros bicornis* was historically widely distributed in southern Africa (du Plessis 1969; Skead 1987; Rookmaaker 1989). They were found in almost all habitats except the central highveld and grasslands of the Free State, Gauteng and Lesotho, the southern Kwa-Zulu Natal and Transkei coastal plain, the arid Kalahari and Namib desert. However, by 1900 the black rhinoceros was almost exterminated throughout most of its range in southern Africa through hunting activities, surviving only in relatively small numbers in a few isolated areas in the region. Elsewhere in Africa the black rhinoceros fared better and through strict protectionist policies by conservation organisations throughout the continent the population recovered to around 70 000 animals by the 1960s (Cumming, du Toit & Stuart 1990). However, this deteriorated rapidly through an increase in poaching activities and the population declined to less than 2600 by late 1995 with the vast majority of these animals being restricted to southern Africa.

As a result of this crash and the consequent increased importance of the southern African populations, the conservation of black rhinoceros is a priority for most conservation organisations in the subregion. This culminated in the acceptance of a regional black rhinoceros conservation plan (Brooks 1989; Brooks & Adcock 1997). The South African National Parks (SANP) with its large number of parks of varying sizes in diverse habitats, and populations of three of the four recognised black rhinoceros ecotypes is in a unique situation with respect to implementing this conservation strategy. It is therefore essential that the SANP has its own conservation plan. This must cater for the diversity of management requirements associated with each of the three ecotypes, the diversity of parks harbouring the rhinoceros and the expansion plans for a number of the parks.

Black rhinoceros systematics

Systematics, with all its problems, is central to the conservation and management of any species. The importance of this issue increases as the species comes under threat through declining population sizes and fragmentation. The black rhinoceros is in this position and it is thus listed as endangered (Appendix I of CITES). Moreover, its systematics are in a quandary.

Although the black rhinoceros had a virtually continuous distribution from southern Africa, through East Africa into West Africa, taxonomic studies based upon rather insufficient morphometric samples have tended to taxonomically split the species. Zukowsky (1964) initially split the species into a multitude of "subspecies" or "races", which Groves (1967) later partially lumped into seven subspecies, with three suggested to occur in southern Africa. *Diceros bicornis* cf *bicornis*, also known as the Cape rhinoceros, was thought to have ranged throughout the former Cape Province and southern Namibia and was the only subspecies considered to be extinct in the subregion (Rookmaaker & Groves 1978). *Diceros b.* cf *minor* which was suggested to range from Natal, through Moçambique and Zimbabwe and possibly into northern Namibia survived in relatively small isolated populations in these areas. The *D. b.* cf *chobiensis* population was suggested to be very localised to southern Angola, the Caprivi in Namibia, and northern Botswana. It is now thought to be extinct.

Owing to the inadequate sample sizes these "subspecies" classifications were later discounted by du Toit (1987). Although further research using molecular and mitochondrial DNA analyses revealed that the "subspecies" were minimally distinct, with differences being trivial and in fact less than that expected within any single large species population (Ashley, Melnick & Western 1990 ; O'Ryan, Flamand & Harley 1994), a 'minimum regret strategy' was advocated until further support for lumping/splitting ecotypes emerges (Amato & Ryder 1992). Thus the African Rhino Workshop (Cincinnati, October 1986) decision to recognise, for practical management purposes, four "subspecies" or ecotypes within Africa still holds. These include:

a. South-western ecotype (*D. b.* cf *bicornis*) from Namibia.

b. South-central ecotype (*D. b.* cf *minor*) from Natal, Zimbabwe through to southern Tanzania

c. Eastern ecotype (*D. b.* cf *michaeli*) from Kenya and northern Tanzania.

d. North-western ecotype (*D. b.* cf *longipes*) of Cameroon and CAR.

The two southern African ecotypes were principally separated on their body size and aridity of their environments. With the surviving Namibian animals being generally larger in body size (Joubert 1970) and within the same biogeographic region as the dry Northern and Western Cape provinces of South Africa, Hall-Martin (1986) suggested that the Namibian population would have shown closer affinities with the supposedly 'extinct' Cape rhinoceros (*D. b.* cf *bicornis*) than the south-central ecotype *D. b.* cf *minor*) from the moister eastern seaboard. These suggestions led to the recognition of the arid-adapted south-western ecotype and hence re-emergence of the *D. b.* cf *bicornis* subspecies description, which is still currently debated (Rookmaaker 1995). Furthermore, Knight and Hall-Martin (1993) proposed a policy that was accepted by the Rhino Management Group (RMG) to maintain the geographical separation of these two local ecotypes in southern Africa using the 500 mm rainfall isohyet as a rough separating line (Fig. 1).

This reasoning formed the cornerstone of the motivation to repatriate the ecologically appropriate ecotype into national parks in South Africa. The arid-adapted south-western black rhinoceros ecotype was repatriated initially into Augrabies and Vaalbos National Parks and later into Karoo National Park and the Buffelskuil section of Addo Elephant National Park, while the south-central ecotype (*D. b.* cf *minor*) has been repatriated into Kruger and Marakele National Parks. The population of the extralimital eastern ecotype (*D. b.* cf *michaeli*) in the elephant camp of the Addo Elephant National Park was established when no surplus *D. b.* cf *minor* could be obtained from Zululand, well before the debate on genetic sub-populations came to the fore.

Conservation principles

Management and research collectively entails two activities namely maintaining the existing populations and establishing new populations. Both of these activities have certain conservation principles and recommendations associated with them (Brooks & Adcock 1997) as briefly discussed below:

1. Maintenance of existing populations

The survival of animals within their natural habitat is central to the conservation of the species. This requires:

a. Their protection through active anti-poaching operations, legal status, intelligence (Knight 1995). Security staff levels should ideally be increased to about one man per 10-20 km².

b. Maximizing ~~their~~ black rhino productivity by maintaining the population size at their estimated potential maxi-

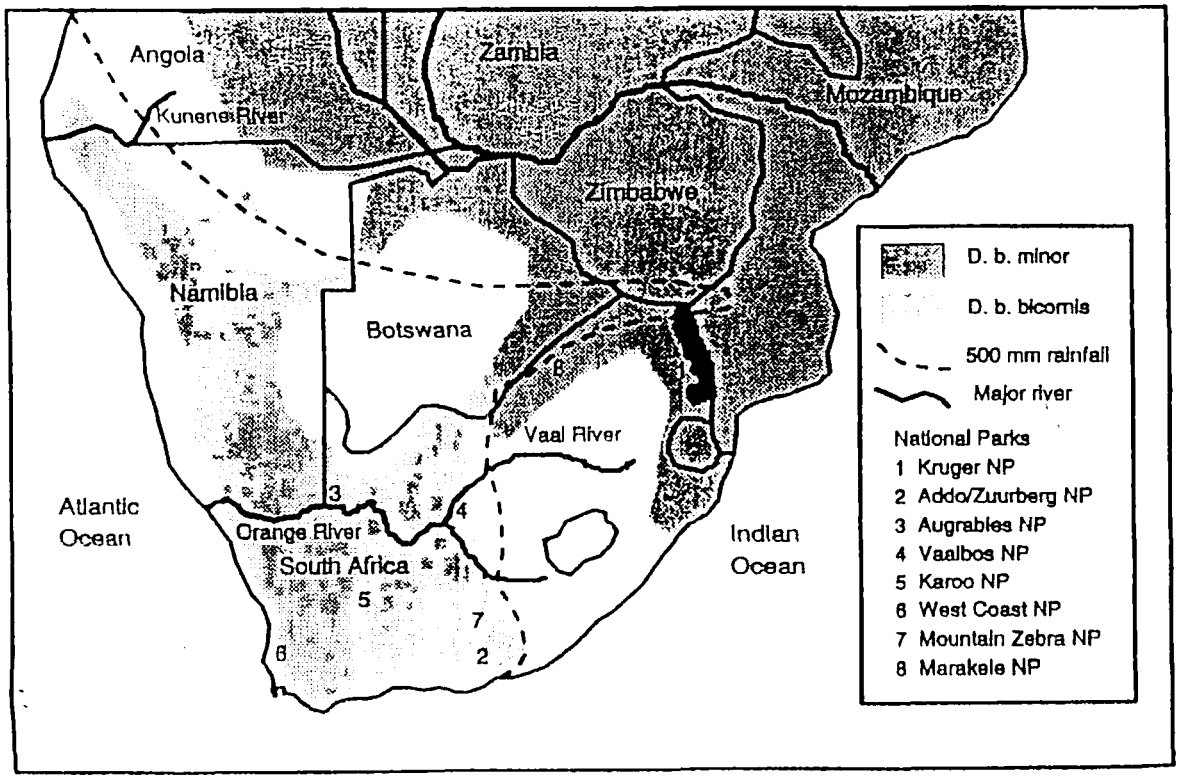

Fig. 1. Historical distribution of *D. b. bicornis* and *D. b. minor* in southern Africa in relation to some national parks

mum productive carrying capacity (EMPCC) (roughly 75% of the estimated ecological carrying capacity (ECC)) (Emslie 1993). This can be maintained through the removal of animals from the population.

c. The maintenance of genetic diversity through the establishment of populations with an effective population size (Ne) >50. In the event that the size of an area is not conducive to this single population approach, the metapopulation strategy of managing a number of populations as a single unit is advocated in which animals are rotated between populations (Gilpin & Hanski 1991; Foose 1992).

d. Manipulation of the habitat to suit black rhinos. This includes monitoring other competitors such as elephant, eland and kudu, as well as altering the habitat directly (through fire, provision of water) to enhance feeding opportunities for the rhinoceros (Emslie & Adcock 1994).

e. Monitoring the population size, and age and sex composition is essential to the entire management process.

2. Establishment of new populations

This activity forms a crucial element of the conservation strategy as it not only extends the species range and available habitat but it also has the advantage of spreading the population in the event of catastrophic events such as disease, poaching or floods. However, the cost-benefit of the population sizes, biological importance and viability need to be measured against the management costs. Salient points needing attention before establishing new populations include:

a. Potential areas need to be assessed for their suitability based upon the quality and abundance of vegetation suitable for rhinoceros, the carrying capacity and the security of the population.

b. Ideally the new area should be large enough to have an ECC of over 200 animals but should not be less than 20 animals.

c. In order to maximize genetic heterozygosity the founder population should be a minimum of 10 animals and should not exceed 50% of the ECC.

d. The provision of animals for the captive breeding programmes should conform with the recommendations of the regional management plan (Brooks & Adcock 1997).

3. Metapopulation management

The idea of a metapopulation was first advocated by Levins (1969) who described a metapopulation as "a population of populations". A metapopulation is linked with the processes of population turnover, extinction and colonization. Although of a similar vane to island-biogeographic theory there is no 'mainland' from which islands are colonized but all the populations are considered as islands interacting with each other, all with a probability of extinction and recolonization (Gilpin & Hanski 1991). The idea of a metapopulation approach to managing biological resources is viewed as a means of tackling the conservation of fragmented populations such as the black rhino. By transferring individuals between populations (at some predetermined rate) it may be possible to maintain the effective population size of the metapopulation below that of a single panmitic population. It would also have the advantage of preserving (or limiting the loss of) the genetic heterozygosity of the population, as well as reducing the chances of stochastic catastrophic events eliminating the entire population.

Many isolated black rhinoceros populations are of such a size that they theoretically offer little long-term sustainability. But by transferring individuals between such populations the smaller populations maintain an active role in the single larger metapopulation. This is being advocated for the conservation of the *D. b.* cf *bicornis* populations under the SANP's control. Although no hard and fast rules exist it is recommended that the transfer of a breeding individual once a generation (7-10 years) between populations should suffice in maintaining the genetic heterozygosity of individual populations and the metapopulation (Foose, Lacy, Brett & Seal 1992). However, managing black rhinoceros in such a way has associated risks as about 20-30% of translocated animals die during the capture and post release phase (Adcock 1995). It is therefore imperative that these risks should be eliminated as far as possible.

The following recommendations are proposed:

a That sub-adults (age class C-E: 2-6 years of age) should be removed from populations at EEC (Knight 1993a) for supplementing other populations or for the establishment of new populations (although they should preferably be introduced with adults for social reasons).

b. The introduction of animals into established populations should be via separate fenced-off introduction areas (termed 'vacuum' areas), which after a certain period (few months to a year) are incorporated into the main rhinoceros area by the dropping of fences.

c. The adult sex ratio should ideally be 1 male:2 females, but adapted for each park's circumstances (see below).

d. Breeding bulls should be transferred between parks once every six or seven years and should also be via the above introduction protocol in the event that

another bull/s already exist in the established population.

Objectives of rhinoceros conservation in the South African National Parks

As the SANP (Anon 1994) endorses the basic conservation objectives of the IUCN (Eidsvik 1990), the conservation of rhinoceros theoretically becomes a sub-goal within this framework. However, the demise threatening the black rhinoceros has raised its overall importance, where specific goals of establishing 'viable' populations of rhinoceros as quickly as possible in national parks within the former ranges of the ecotypes have been set. The SANP has thus committed itself to:

1. The conservation of the three black rhinoceros ecotypes (*D. b.* cf *minor*, *D. b.* cf *bicornis* and *D. b.* cf *michaeli*) as separate entities until such time that it is scientifically proven that the ecotype distinction is not valid or that the integration of their separate gene pools would not be detrimental to the greater population.
2. Attempt to breed up as quickly as possible and conserve genetically viable populations of at least 3500 *D. b.* cf *minor*, 200 *D. b.* cf *bicornis* and 75 *D. b.* cf *michaeli*.
3. Maintain rhinoceros security as a priority in each park.
4. Support captive breeding programmes, provided they play a positve contribution towards the conservation of *in situ* rhinoceros populations.
5. Conform to the South African black rhinoceros conservation plan.

Current and future proposed management of each ecotype

1. South-central (*D. b.* cf *minor*)

This ecotype is typically found in the mesic savannas of southern and eastern Africa. Within South Africa it was historically restricted to the former northern and eastern Transvaal and Natal areas.

Populations were decimated by the 1900s with a remnant population left in Natal and the lowveld, with the

Table 1
Sex and age composition of black rhinoceros introduced to the Kruger National Park 1971-1998

Date	Region in KNP	Origin	Adult		Immature		Mortalities	Total
			Male	Female	Male	Female		
1971	South	A	9	9	1	1		20
1972/10	South	B	4	6	(2)	-	2 Imm males	10
1977/09	South	A	-	2	-	-		2
1979/10	South	C	-	1	-	-		1
1980/10	South	A	5	3	-	-		8
1981/05	Central	D	1(2)	-	-	-	1 adult male	1
1981/07	Central	A	8	5	2	1		16
1981/08	South	A	2	4	-	-		6
1982/07	Central	A	3	-	-	-		3
1989/05	Central	C	1	-	-	-		1
1989/09	Central	E	3	2	2	1		8
1989/04	South	E	-	1	-	1		2
1997/12	Central	A	2	3	-	1		6
Total South			20	26	1	2		49
Total Central			18	10	4	3		35
Total KNP			38	36	5	5		84

A futher three males and two females died soon after release in the KNP

Origin
A - Hluhluwe/Umfolozi Complex, KwaZulu-Natal
B - Zambezi Valley, Zimbabwe
C - Strays from Gona-re-Zhou (ex Zambezi Valley) or Mozambique
D - Addo Elephant National Park (KwaZulu-Natal 1977)
E - Ndumo Game Reserve, KwaZulu-Natal

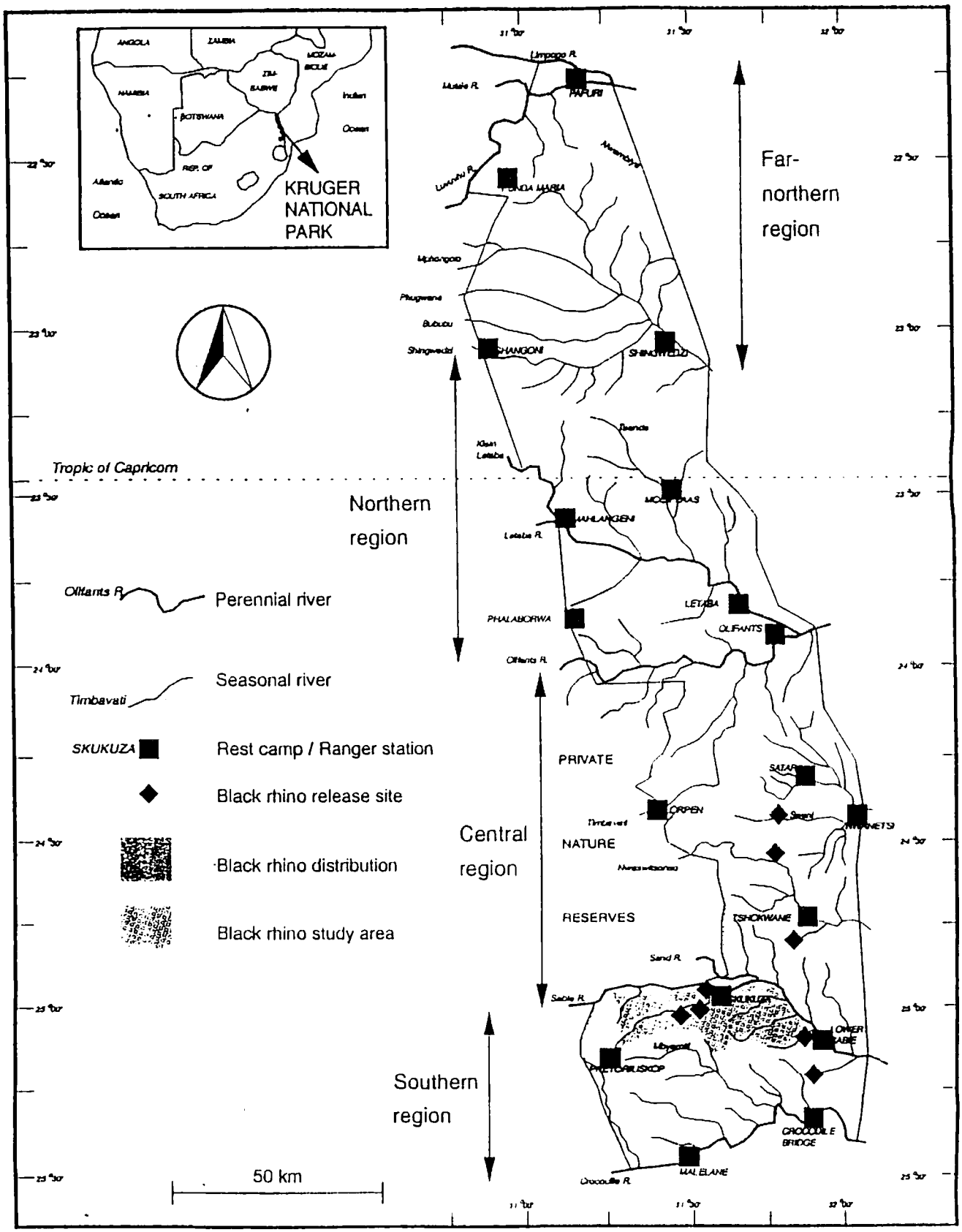

Figure 2. Black rhino distribution in the Kruger National Park.

latter disappearing in the Kruger National Park (KNP) in the 1930s.

Three national parks (Kruger, Marakele & Vhembe/Dongola) occur in the former range of this ecotype, yet only Kruger and Marakele are presently stocked with rhinoceros and will be covered by this report. Vhembe/Dongola is presently too small and in too early a stage of development to offer any immediate prospects for rhinoceros conservation although in conjunction with the Tuli Block Game Reserve in Botswana there is great potential for the introduction of black rhinoceroses in the future (Knight, Bezuidenhout, Castley & Pienaar 1997).

A. Present populations

a. The Kruger N.P. - Current status

The last of the lowveld's indigenous stock of rhinos was seen in 1936 in the Nwatimhiri bush in the KNP. Although plans had been made since the early 1950s to reintroduce black rhinoceros to the KNP, logistic and financial problems prevented it until between 1971 and 1989 when a total of 81 animals were repatriated to the Southern and Central Districts of the KNP from Hluhluwe-Umfolozi, Mkuzi and Ndumu Game Reserves in Natal, the Zambezi Valley in Zimbabwe, and from the Zimbabwe border area of northern KNP (Table 1) (Hall-Martin 1990). A further six animals, originally from Hluhluwe/Umfolozi, were obtained from Thaba Tholo ranch in an exchange for six *D. b.* cf. *michaeli* from Addo in December 1997 (Table 1). Three of the introduced animals (2 males, 1 female) died in captivity and a further three males and two females died shortly after release. The population has increased to in excess of 250 animals, making it the second largest population after Hluhluwe-Umfolozi Complex (Pienaar 1995). The original founder population is large enough to offer both genetic and demographic viability and stability for the long-term (>200 years) (Foose *et al.* 1992). Moreover, with the

Table 2
Present (as of 1998) and short-term (10 years) land acquisition prospects and their expected black rhino carrying capacity (ECC) in South African national parks

Ecotype	Park[a]	Rhino stocking density (ECC)(km²)	Present parks			Short-term park expansions		Management strategy [b]
			km²	Rhino density (km²)	Rhino #s	km²	Rhino #s	
D. b.minor	KNP	0.18-0.21	19485	0.01	230	19485[c]	2500-3200	Stand alone
	MNP [d]	0.10-0.13 (high) 0.13-0.18 (low)	380 55	0.02 0.22	8 12	600 110	60-75 14-20	Meta - KNP
D. b. bicornis	VNP	0.05-0.07	180	0.04	7	661	33-46	Meta
	AFNP	0.04-0.06	89	0.07	6	106	4-7	Meta
	KRNP	0.05-0.07	330	0.01	4	519	26-36	Meta
	AENP	0.51-0.70	121	0.06	7	168	86-117	Meta/stand alone
	MZNP	0.05-0.07	65	-	0	232	12-16	Meta
	WCNP	0.05-0.07	270	-	0	270	14-19	Meta
D. b. michaeli	AENP	0.51-0.70	107	0.32	34	117	60-82	Meta - zoos/E. Africa
Totals *D. b.minor*			19420		245	19420	3552-4159	
D. b. bicornis			1056		24	1988	177-243	
D. b. michaeli			107		34	117	60-82	

[a] National parks: KNP - Kruger; MNP - Marakele; VNP - Vaalbos; AFNP - Augrabies Falls; KRNP - Karoo; AENP - Addo Elephant; MZNP - Mountain Zebra; WCNP - West Coast
[b] Management strategy will be either a metapopulation or stand-alone approach.
[c] This is subject to a considerable increase if the transfrontier park with Mozambique comes into existence.
[d] 'High' - mountain sourveld areas; 'Low' - low lying bushveld areas.

founders originating from four separate original populations, the KNP *D. b.* cf *minor* population is genetically the most diverse in South Africa.

The sex ratio of the released black rhinoceros was 43 males and 41 females (Table 1). Of these 22 males and 13 females were released in the Central district of the KNP and 21 males and 28 females were released in the Southern district. The sex ratio of the animals released in the Central district is skewed towards males and this situation will have to be addressed in future. The sex ratio of adult black rhinos recorded in the study area in the Southern KNP is at parity and the age structure of this sub-population is 60 % adults, 23 % sub-adults and 17 % juveniles (Pienaar 1995).

- Future expansion options

Besides the possible doubling in size of the protected area available to rhino through a proposed transfrontier agreement with Mozambique, there are no plans to increase the size of the KNP. By virtue of its size and low density of rhinoceros (0.09 rhino/km²) the park offers ideal prospects for rhinoceros conservation (Fig. 2). A rough estimate of the ECC density for the southern KNP is 0.2 rhino/km² which amounts to an estimated ECC of 1 440 black rhinoceros in the area south of the Sabie River. The overall ECC for black rhinoceros in the whole KNP would probably range from 2 500 - 3 200 animals (Table 2). More introductions of black rhinoceros into unoccupied areas of the KNP need to take place. These areas contribute greatly to the potential black rhinoceros carrying capacity of South Africa and must receive more black rhinoceros if the conservation goal for the ecotype is to be reached.

- Proposed population management

Since their introduction the policy of non-intervention has been advocated, with the objective of allowing the population to increase as rapidly as possible. Because of Kruger's large size and the wide range of suitable black rhinoceros habitats, it has the potential to become the largest population in South Africa with more than 3000 animals (Table 2), hence its importance in the regional conservation plan (Brooks & Adcock 1997). The overall population has only been monitored through the annual aerial survey of the park. This unfortunately, like similar aerial surveys of other savanna systems, has proved unsuccessful in effectively estimating rhinoceros population sizes (Goddard 1967). However, more precise estimates of population increase, intercalving intervals and dispersion patterns not obtainable from the wider survey were estimated through monitoring a specific subpopulation (of which some of the animals were fitted with radio transmitters) in the Skukuza area on a more regular basis over a number of years. Although the sample was restricted to a single sub-population it reflected a locally healthy population situation which is probably not found in the Central District of the Kruger National Park owing to a distorted sex ratio in favour of males among the re-introduced black rhino.

- Monitoring

Given the KNP's large size and relatively small rhinoceros population a combination of three monitoring methods are to be used as follows:

1. Plans are afoot to implement the individual ID programmes that are currently being used successfully in a number of smaller game reserves. However, the KNP is a very large national park and game guard density is comparatively low at about 1 game guard/100 km². The black rhinoceros population in the KNP is still relatively small with only a few ranger sections holding more than 30 black rhino. The bigger the black rhinoceros population grows the more difficult it will be to implement such an individual indentification programme. Staff members need to be trained and provided with binoculars before they will be able to make accurate observations on black rhinos.
2. A photographic method, as successfully used in Ethosha National Park could be similarly implemented in the KNP. Animals are photographed at night at waterholes during the dry season (Cilliers 1989). This method yields excellent results but specialized camera and flash equipment is necessary. Although the KNP has much more water than Etosha, this method could still be useful in the KNP. Individual water-points need to be investigated beforehand to determine where black rhinoceros drink.
3. Another source of information is the annual buffalo and elephant aerial surveys in the KNP. Black rhinoceros are often encountered and it is possible to photograph these animals from the air. These observations provide valuable information on black rhinos outside the study area.

To monitor the black rhinoceros population in the KNP effectively a combination of the above three methods is proposed. There is an urgent need to launch an effective black rhinoceros monitoring programme in the KNP as soon as possible, given the desperate position of the black rhinoceros elsewhere in Africa.

- Security

Poaching in the KNP is a problem that will probably always exist. There are few areas in the KNP where poachers would not encounter rhinoceros within 10 to 20 km from the boundary. To date, rhinoceros poachers in the KNP have not concentrated their activities in areas with high rhinoceros densities. Since 1990 a total of 34 white rhinoceros and one black rhinoceros are known to have been poached, which probably underestimates the true situation. During 1995 only

Table 3
History of the *D. b. minor* population in Marakele National Park
Abbreviations: f=female; m=male; Dd=dead; Mv=moved; Bn=born

Section	No/Name	Sex	Dame/ born (±age yrs; or age class)	Intro. date*	Years 93	94	95	96	Notes
Waterval	Theresa	f	? (20)	10/93 (KNP)	In				
	Assi	f	? (15)	10/93 (KNP)	In	Mv			To Duikers Pan
	mwf2	f	Theresa 6/94			Bn	Dd		Injuries from fighting
	Vulindlela	m	? (8)	10/93 (Umf)	In				
	mwf1	m	Assi 3/94			Bn/Dd			Died from ? Carcass not found
Den. (km²)					0.23	0.38	0.23	0.15	
Duikerspan	Vega	f	? (5)	1/94 (KNP)		In			
	Assi	f	? (15)	9/94 (Waterv)		In			
	Pumbi	m	? (15-20)	1/94 (KNP)		In			
	mdp1	m	Vega 6/94					Bn	
Den. (km²)						0.21	0.21	0.28	
Kwaggas-vlakte	Mokgalabe	m	? (old F)	6/96 (Umf)				In	Mv Swarthoek 30/10
	Zootie	m	?(2-3)	6/96 (Umf)				In	Mv Hugo plan 30/10
	Catherina	f	?(15)	8/96(KNP)				In	
	Nyani	f	Catherina/96					Bn	Nyani to ARC
	Nicola	f	Catherina/93	8/96(KNP)				In	Dd. 17/10/90
Den. (km²)								0.53	
Zwarthoek	Carissa	f	?(D)	?/96(KNP)				In	
	Kate	f	?(F)	?/96(KNP)				In	
	Punyana	f	Kate(C)	?/96(KNP)				In	
	Sesana	f	?(E)	?/96(KNP)				In	
	Irene	f	?/94(D)	?/96(KNP)				In	
	Hugo	m	?(E)	?/96(KNP)				In	
	Hlanguleni	m	?(E)	?/96(KNP)				In	
	Anton	m	?/91(E)	?/96(Umf)				In	
Den. (km²)								0.02	
Hugos	Ria	f	?/91(E)	?/96(KNP)				In	
	Rams	m	/(7-8)(F)	?/96(Umf)				In	
Den. (km²)								0.80	
Total					3	0.01	7	0.02	
Den. (km²)					5	0.01	20	0.05	

* Umf = Umfolozi Game Reserve; Waterv = Waterval section

one white rhinoceros was poached in the KNP but sporadic poaching incidents are expected in future.

It has been suggested that black rhinoceros should be moved out of areas where poaching is prevalent. This suggestion is not supported for the following reasons:

i. It would be a temporary measure as other rhinoceros would quickly recolonize such vacant areas.

ii. Such an operation would be very expensive and these funds could be utilized more effectively elsewhere.

iii. Poachers are highly mobile, able to shift their areas of operations before conservation authorities are normally able to detect such alterations.

It is therefore suggested that anti-poaching operations should be concentrated in areas where rhinoceros poaching is prevalent rather than moving rhinoceros out of problem areas. Anti-poaching personnel and equipment could temporarily be recruited from other quieter sections to alleviate problems in high density rhinoceros areas. The fast growing white rhinoceros population in the KNP shields the smaller black rhinoceros population from poaching. Rhinoceros poachers do not discern between the two rhinoceros species and shoot the first suitable animal. In 1993 a total of 1 876 white rhinoceros were counted in the KNP and the population rate of increase is estimated to be about 9 % per annum (Viljoen *et al.* 1994). Thus the 12 white rhinoceros that were poached in 1994 represents only 0.6 % of the population. If the number of white rhinoceros poached annually can be contained to less than 1 % of the population, the white rhinoceros population in the KNP will continue to expand at a healthy rate and screen the smaller black rhinoceros population.

A big problem in some African countries where rhinoceros populations were decimated was massive corruption in conservation organizations. Poaching by staff is the biggest threat to any park's rhinoceros population. It has happened twice in the KNP that staff members were involved in rhinoceros poaching. If large scale corruption ever sets into the South African conservation organizations, it will be impossible to protect rhinoceros populations in nature reserves. It would then be better to move the animals onto private land where the people have the ability to protect them. Corruption within staff can be limited by keeping morale high, creating a pleasant working environment and by paying staff decent salaries. Corruption is at present not a problem within the South African National Parks.

b. Marakele NP.

- Current status

The park is presently 440 km² in size and is situated at the western extreme of the Waterberg Mountain range of the Northern Province. Since its beginnings in the mid 1980s, the acquisition of further pieces of land (in some cases apart from the main segment of the park), in line with the park's development plan (Hall-Martin, Novelile & Knight 1995), has led to the need to manage separate units. With the intention of getting the park operational with a full quota of species as quickly as possible, there has been a concerted drive to stock the park and its isolated sections with the hope that most of the separated areas would be incorporated into the greater park in the near future. Black rhinoceros have formed part of this introduction programme. The mountain sourveld vegetation with its low nutrient soil status and moderate incidence of frost that covers the greater portion of the park (ca 384 km²) is expected to have a relatively low ECC of between 0.10 – 0.125 rhino/km², while the much smaller (ca 55 km²) lowland bushveld areas with their rare frost and medium rich soils are expected to have a slightly higher ECC of between 0.13 – 0.18 rhino/km² (Table 2).

The intial introduction of three animals into the bushveld Waterval section soon revealed that the ECC had been over estimated, which resulted in a shift of one adult to bolster the Duikerspan section (Table 3). Animals have also been established in other lowland areas such as Kwaggasvlakte and Hugo's place at slightly higher than recommended stocking rates with the plan of consolidating the separate sections through land purchases as a way of alleviating the high stocking rate in the founder areas. However, as this process has been delayed further shifts in the animals have been made to address the unsatisfactorially high stocking rate. Animals have also been introduced to the larger Zwarthoek highland areas at a density of 0.02 rhino/km².

- Future expansion options

Hall-Martin *et al.* (1995) proposed a further expansion of the park into the low lying bushveld areas to offer the large herbivores the altitudinal and habitat variety necessary for seasonal natural movements (Fig. 2). Thus, the acquisition of farms separating the Waterval, Geelhoutbos, Duikerspan and Hugos place need be undertaken as quickly as possible. This would effectively double the size of this habitat to about 110 km², which could theoretically carry between 14 to 19 animals.

- Proposed population management

The proposed ECC for the different habitats should not be exceeded. Thus, the stocking of the small, fenced lowland areas (Kwaggasvlakte, Waterval & Hugo's areas) needs to be given immediate attention. In order to maximize breeding it is preferable to stock the park at recommended EMPCCs of 0.08 – 0.10 and 0.10 – 0.14 rhino/km² for the higher lying and lowland areas respectively. Thus for the lowland and mountain areas a minimum of 700 and 1000 ha should be allocated to each animal, respectively.

At least three animals (preferably all except the old bull) from Kwaggasvlakte and the adult female from Hugo's place should be removed, preferably to another section of the larger mountain section.

The vacant bushveld sections of Geelhoutbos (3 km²) and Zandfontein (ca 4 km²) should not be used for these animals owing to their small size. However,

Table 4.
History of the *D. b. bicornis* population in Augrabies Falls National Park.
Abbreviations: f–female; m–male; Dd–dead; Mv–moved; Bn–born.

No/Name	Sex	Dame/ born	Intro. date	Years												Notes
				85	86	87	88	89	90	91	92	93	94	95	96	
AU1	f	?	8/85 (ENP)*	Dd												Dead: cliff fall
AU2 Blompot	f	?	8/85 (ENP)			AU4 f*		AU8 f		AU11 f		AU12 f		AU14 f		
AU3 Plootjies	f	?	8/85 (ENP)							AU10 f			Dd			Dead: unknown causes Dec 92.
AU9 Shibula	f	?	8/90 (ENP)						In				AU13f			
AU4* Blommetjie	f	Blompot Oct87				Bn						Dd				Dead: capture Nov93.
AU8 Cathrina	f	Blompot Oct89						Bn				Mv				Moved to KRNP Oct93.
AU10 Saskia	f	Plootjies Apr91								Bn			Dd			Dead: capture Aug94.
AU11 Spook	f	Blompot Oct91								Bn			Mv			Moved to KRNP then AENP on Dec94.
AU12 Nadap	f	Blompot Oct93										Bn				
AU13 Tande	f	Shabula Sep94											Bn			
AU14 Khoro	f	Blompot Dec95												Bn		
AU5 Arrie	m	?	8/85 (ENP)										Mv			Moved to AENP Oct94
AU6 Wildeman	m	?	8/85 (ENP)												Mv	
AU7 Stompie	m	?	8/85 (ENP)						Mv							Moved to VNP Mar90.
Total				6	5	6	6	7	7	9	9	9**	8	6	6	
Density (km^{-2})				0.11	0.09	0.11	0.11	0.12	0.12	0.16	0.16	0.10	0.09	0.07	0.07	

* Animal ear marked with this number.
** Rhino camp increased from 55 to 89 km^2, and totals as of March of each year.
' – Etosha National Park

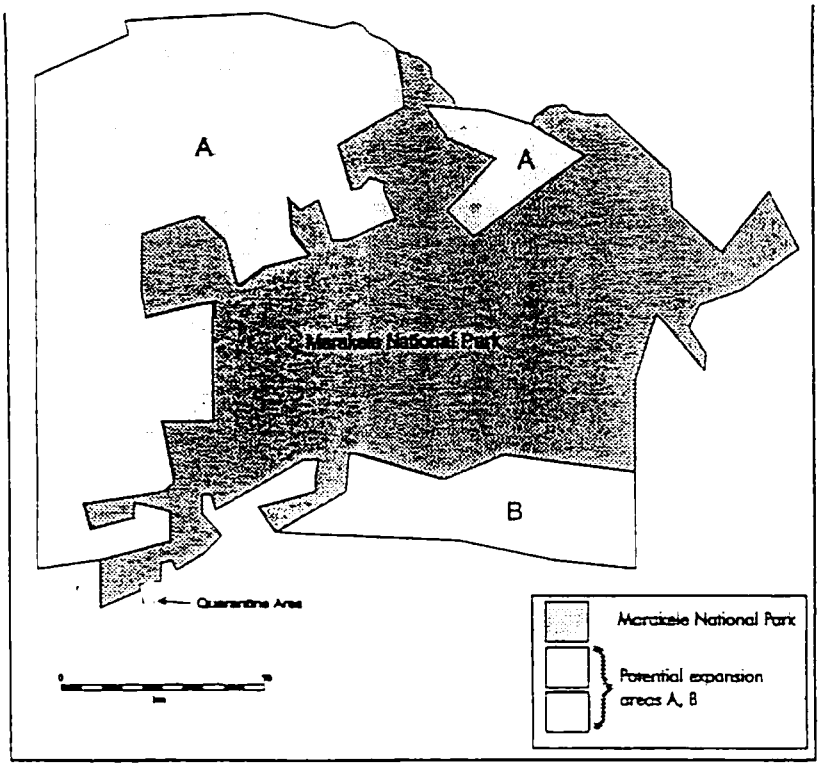

Fig. 3. Marakele National Park and proposed expansion areas

these two sections could be used as temporary holding areas for surplus bulls. Although, Waterval is overstocked with two animals, the calves produced from the pair will need to be removed at weaning to reduce the pressure on the area, or alternatively, expand the area as planned.

- Monitoring & security

The confinement of animals to fenced off sections in the begining facilitates monitoring, however once the park is consolidated, this task will become more difficult given the hilly terrain, small population size, and small ranger corps. The ranger density will also drop from the ideal 1 man/13km^2, well within the bounds of that recommended by Leader-Williams & Albon (1993). It may be therefore advisable to fit each animal with a radio-transmitter which would faciliate their monitoring from the ground, particularly in the early introduction phases. Failing that helicopter monitoring of the population should be preferabiy undertaken twice a year in conjunction with regular ground monitoring (through tracking) where the following information is recorded: date, time, position, number and age/sex composition, condition and general behaviour. A veld computer that is in the process of being developed may prove an ideal tool for this type of data recording particularly by illiterate rangers and could be used in most parks.

The above monitoring programme will form an integral part of the overall security operation around the rhinoceros population. Paramilitary training must form an important basis of the training of the ranger corps designated with this operation. In conjunction with this aspect there also has to be a concerted effort at establishing an information network in the surrounding communities so as to preempt any potential poacher activity (Knight 1995).

2. South-western (*D. b. cf bicornis*)

The repatriation of *D. b. cf bicornis* populations into two arid South African national parks (Augrabies & Vaalbos) in 1985 and 1987 respectively, was the initial phase of a plan by the SANP to repatriate this ecotype to its former range in South Africa (Hall-Martin 1986). The urgency of this was boosted by the possibility of an increased poaching pressure on the Namibian populations at the time as a result of the crash of Zimbabwean rhinoceros populations. Furthermore, with the bulk (95 %) of the over 500 *D. b. cf bicornis* in Namibia being restricted to two areas, it was argued that other secure populations, preferabiy in sanctuaries or small manageable areas, needed to be established outside Namibia yet in the ecotype's former distribution. Further justification for this comes from the fact that no *D. b. cf bicornis* were held in captivity and

Table 5.
History of the *D. b. bicornis* population in Vaalbos National Park.
Abbreviations: f–female; m–male; Dd–dead; Mv–moved; Bn–born.

No/Name	Sex	Dame/ born	Intro.	Years									Notes
			date	87	88	89	90	91	92	93	94	95	96	
Paru	f	?	8/87	In				Benji		Estee		Mlel		
Ubeghan	f	?	8/87	In	Ngarall		Banga		Vernon		Dulu			
Tshukudu	f	?	8/87	In	Borka			Kenge			Maleka		??	
Nkhombe	f	?	8/87	In				Kora					Mozib	
Ngara I	f	Paru ±Jun 86	8/87	Dd										Dead: lightning
Borka	f	Tshukudu Oct 88			Bn					Mv				To KRNP 10/93
Kenge	f	Tshukudu Jun 91						Bn			Mv			To AENP 10/94
Kora	f	Nkhombe Jul 91						Bn		Dd				Died 11/93
'Estee'	f	Paru Oct 93								Bn			Mv	To AENP 2/96
Mlel	?	Paru Oct 95										Bn		
Mozib	?	Nkhombe Jan 96											Bn	
??	?	Tshukudu Apr 96											Bn	
Chipenbere	m	?	8/87	In						Mv				To KRNP 10/93
Recombe	m	?	4/89		In/Dd									Died: broken jaw
Stompe	m	?	3/90			In/Dd								Died: Vehicle accident
Stark	m	?	9/90			In/Dd								Died: Anaemia?
Karos	m	?	9/90			In								
Ngara II	m	Ubeghan May 88			Bn								Mv	To AENP 4/96
Benji	m	Paru Jan 91					Bn					Mv/Dd		Moved AENP, died:babesia
Banga	m	Ubeghan Jun 91						Bn		Dd				Died: Fighting 3/93.
Vernon	m	Ubeghan Apr 93								Bn		Dd		Died: Fighting 3/95.
Maleka	m	Tshukudu Jan 94									Bn		Mv	To AENP 2/96
Dulu	m	Ubeghan Jan 95										Bn		
Total No.				6	5	7	10	9	12	13	11	11	9	
Density (km^{-2})				0.03	0.03	0.04	0.06	0.05	0.07	0.07	0.06	0.06	0.05	

mere were no plans to incorporate them into the captive breeding programme (Foose 1992).

Given the relatively small parks into which the rhinos were to be repatriated it was decided from the outset that a metapopulation approach (Gilpin & Hanski 1991) to managing the *D. b. bicornis* population would be implemented. This would reduce the chance of the entire population succumbing to some stochastic event such as drought, the probability of which was considered rather high given that most of the parks were in arid areas prone to such events (Tyson 1986). Thus, the initial founding population of 12 animals (plus a further three later added) brought in from Etosha was subdivided between two satellite parks, Augrabies and Vaalbos, with a plan to interchange individuals, particularly breeding males, once the first generation reached breeding age. The breeding history of each of these populations is discussed below.

A. Present populations

a. The Augrabies Falls N.P. population

- Current status

Six (3.3) animals were introduced into the 55 km² Bokvasmaak section of the park on the northern bank (Table 4). At that stage negotiations were well advanced towards incorporating a further 600 km² of the adjacent military training ground into the park, increasing the section with rhinos to about 655 km². It was thought that such an area could carry about 30 animals (Brooks 1989) at a conservative ecological carrying capacity (ECC) of about 0.03 rhino/km², that was later increased to about 0.075 rhino/km² based upon densities noted in other arid areas (Knight 1993b).

Although one of the adult females died shortly after release as a result of a fall from a cliff, the population has bred exceptionally well, increasing at a high 11.5% per annum (one of the highest in the subregion (Adcock 1995)). This was principally due to the phenomenal breeding performance of the female Blompot who had a very short inter-calving interval of 2 years. With the addition of another adult female (Shibula) from Lisbon Zoo in 1990 and birth of a further two calves, the population increased to 9 animals by 1992 and an unacceptably high density of 0.16 rhinos/km².

It was in this period that the adult female Plootjies died which may have resulted from the high density. Owing to delays in fencing and changes in the political status of Riemvasmaak, the military ground was never incorporated into the rhinoceros camp, which led to a potential crisis for the rhinoceros population. As a result, the 58.03 km² Waterval farm was purchased. The southern section was added to the rhinoceros camp in 1991, increasing its size to 89 km² and lowering the density to 0.1 rhinos/km², still above the recommended stocking rate.

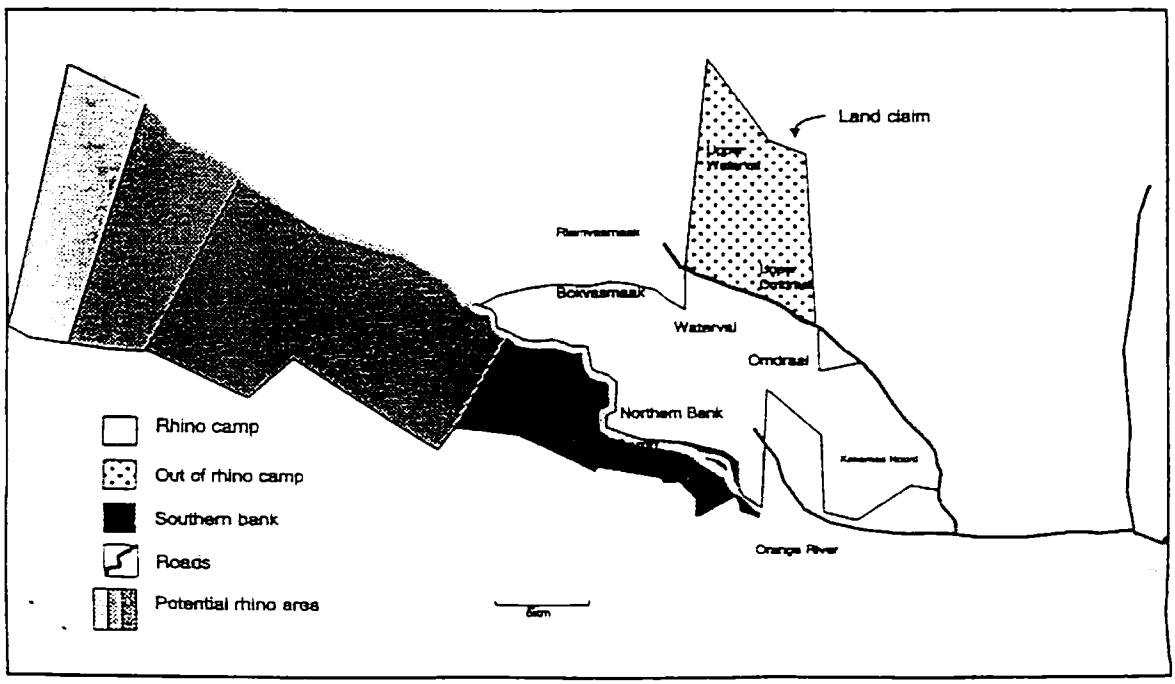

Fig. 4. Augrabies Falls National Park and possible expansion areas.

Table 6
History of the *D. b. bicornis* population in Karoo National Park
Abbreviations: f–female; m–male; Dd–dead; Mv–moved; Bn–born.

No/Name	Sex	Dame/ born	Intro. date	Years 93	94	95	96	Notes
Ngara2	f	Tshukudu	1/94 (VNP)		In	Gamka		
Katrina	f	Blompot	12/93 (AWNP)	In				
Tswaros	f	Blompot	10/94 (AWNP)		In/Mv			Injured through fighting. To AENP
Chipenbere	m	?	8/87 (VNP)		In			
Gamka	m	Ngara2 8/95				Bn		
Total no.				1	4	4	4	
Density (km^{-2})				0.01	0.06	0.06	0.06	

To reduce the stocking rate five animals were removed in late 1993 and 1994, of which two unfortunately died from capture related problems (Table 4). This reduced the density to 0.06 rhinos/km². The captured animals formed the nucleus for two new populations in Karoo and Addo Elephant National Parks. The introduction of Shibula was unique in that it was the first re-introduction of a zoo animal back into the *in situ* free-ranging situation. She was introduced into a separate (ca 1000 ha) fenced-off section located on the eastern extreme of the park. As part of her introduction phase, the old bull Arie was included in her camp in the hope that he would cover her. After about a year the separating fence was dropped and she was allowed to integrate with the remainder of the population.

- Future expansion options

From an analysis of black rhinoceros stocking rates throughout the subregion, Adcock (1995) recommended that the AFNP ECC should be between 0.04 – 0.06 rhinos/km², below the 1993 recommendation. At the parks present size it could not carry more than 6 animals which in itself does not meet the minimum EEC of 20 animals per population. But the SANP's metapopulation approach to managing these populations does in itself not make this a critical matter although the very size of the population opens it to greater chances of catastrophe. There should therefore remain the commitment to further expand the park's size to accommodate a larger population of rhinos.

The park was further expanded by the purchase of the 30.01 km² and 91.2 km² Omdraai and Kakamas Noord properties in 1996, of which 17 km² and 29.5 km² respectively are to be directly included in the present rhinoceros camp by 1998 (Fig 4). Both sections lie to the south of the public road to Riemvasmaak. This would expand the rhinoceros camp to around 136 km² which has a potential ECC of between 6 and 9 animals. These expansions as have been incorporated into the 10 year scenario (Table 2) would account for most of the land between the Riemvasmaak road and the farm land along the northern bank of the Orange River. Unless an alterative to the Riemvasmaak road could be negotiated, or some contractual agreement for additional land can be agreed upon with the Riemvasmaak community the size of the rhinoceros camp will be very much at its maximum size. Alternative approaches could be to purchase further land (Keichenoep and Zwaar Draai) to the north of the Riemvasmaak road to add to the Waterval and Omdraai sections already owned by the SANP, and run it as a separate unit from the rest of the park or consolidate it with the southern section and manage the traffic along the road. The Waterval, Omdraai and Kakamas Noord sections to the north of the Riemvasmaak road already amount to 98.7 km² and with their more open, sparse vegetation and lower ECC of ca 0.04 rhino/km² could potentially carry a further 4 rhino, increasing the area for rhinoceros to 234.7 km². Ideally, to accommodate a minimum of 20 rhinoceros the park will need to be expanded to about 330 km², ie. another 95 km² would need to be purchased.

As an alternative to expanding the park north of the present Riemvasmaak road, the SANP should possibly consider expanding the park along the southern bank of the Orange River to the west in the hope of linking to the proposed Gariep Transfrontier Park (Jardine & Owen 1998). Expansion along the southern bank would be inland of the extensive viticulture along the Blouputs area and would be bissected by a number of public roads which would call for progressive mangement options.

- Proposed population management

Assuming the area of the park will not exceed the 10 year scenario and that the EMPCC for the area is no more than 7 animals, its recommended that the age and sex composition should be maintained as one breeding bull (two at most), two adult females and their progeny up to about three to four years of age. Thus each female could have two calves (of different ages) simultaneously in the park for a year or two. Removal of the 3 – 4 year olds would be in preference to the just weaned two year olds owing to their larger size and greater social awareness.

Any expansions of the parks area beyond present expectations would require a reassessment of the rhinoceros population management strategy.

- Monitoring & Security

Monitoring should consist of at least weekly sightings of all rhinoceros by ranger staff, with data on date, time, position, number and age/sex composition, condition and general behaviour being noted for each sighting. In addition every opportunity that a helicopter is available should be made use of to keep photographic records of each animal.

Although the park has not yet had its security tested, the fact that people known to be antagonistic to conservation and with previous exposure to illegal rhinoceros activities in Namibia, have been repatriated to Riemvasmaak, it may be advisable to not expand north of the Riemvasmaak road but rather wait until the political situation has settled. In the mean time high security awareness of the rhinoceros camp should be maintained through the establishment of a permanent ranger station on the northern bank, up-graded paramilitary training for these rangers and regular overt and clandestine patrolling (Knight 1995). The need for an efficient early warning system in the form of an information network is a necessity in this small park. At the slightest indication of the rhinoceros being exposed to any danger they should be moved forthwith to the following possible sites (in order of preference): the Zuurberg section of AENP, KRNP, MZNP and WCNP.

b. The Vaalbos N.P. population

- Current status

The six rhinoceros (1.5) introduced into the Sydney section of Vaalbos National Park in 1987 grew to a maximum of 13 animals by 1993 but has been reduced to 9 in 1996 through removals and deaths (Table 5). The growth over this period has averaged 6.4% with an above average inter-calving interval of 2.9 years. In spite of this there have unfortunately been a number of deaths, many beyond management control. Over the 10 years, a total of eight animals have died (one to lightning, one to vehicle injuries, two to disease (anaemia & babesia), one to a broken jaw, and three to fighting).

Table 7.
History of the *D .b.bicornis* population in the Addo Elephant National Park.
Abbreviations: f–female; m–male; Dd–dead; Mv–moved; Bn–born.

No/Name	Sex	Dame/ born	Intro. date (from)	93	Years 94	95	96	Notes
Kenge	f	Tshukudu 6/91	1/95 (VNP)			In	Mv	From Kleinvlak to Buffelskuil
Tswaros	f	Blompot 10/91	1/95 (AFNP)			In	Mv	From Kleinvlak to Buffelskuil
Dulu	f	Faru 10/93	5/96 (VNP/KRNP)				In	To Buffelskuil
Arie	m	?	10/94 (AFNP)		In		Mv/ Dd	From Kleinvlak to Buffelskuil, died old age
Ngaral! (Borka)	m	Ubeghan 5/88	5/96 (VNP)				In	To Buffelskuil
Maieka (Tony)	m	Tshukudu 1/94	5/96 (VNP)				In	To Buffelskuil
Total no.					1	3	6	
Density (km^{-2})					0.17	0.52	1.45	

Since introduction the rhinoceros density has varied from 0.03 to 0.072 rhino/km², with the latter density approaching that which was initially recommended by Knight (1993c) based upon natural densities from other areas. With only about 42% of the park considered to offer favourable black rhinoceros habitat it was estimated that the park could not carry more than about 14 animals which led to the translocation of two animals (Chipembere (the breeding bull) and Ngara II female) to Karoo National Park. However, the loss of three calves (all class C-D — 2-3-year olds) through fighting and the injuries inflicted upon another subadult bull (Benji) raised concerns about the parks rhinoceros carrying capacity. During this period of injuries the population density ranged between 0.06 – 0.07 rhino/km². At first it was reasoned that the injuries may have been inflicted by the mothers of the calves during the weaning stage as all the injured animals were in the 2-3 year age class. However, the fact that Benji (a 5-year old bull) also sustained injuries raised suspicions that the bull Karos may have been the culprit as he was just coming into breeding age at the time and the previous breeding bull had been removed from the park shortly before.

- Future expansion options

The future potential for black rhinoceros conservation in the VNP area is good given the presence of mainly game farming and to a limited degree cattle farming enterprises in surrounding properties (Fig. 5). Agreements with the owners of Rooipoort and Pniel to join a greater Vaalbos park complex would raise the conservation area to in excess of 660 km² which at the proposed stocking rate of 0.04 – 0.06 rhino/km² could carry a total of 30 to 50 animals (Table 2).

In the event that these options do not materialise a number of options remain open such as expanding the park across the Vaal River towards the Ghaap plateau which offers some ideal black rhinoceros country. About 147 km², enough to carry a further nine rhino, lies directly opposite the park. Besides offering additional land for rhinos it would also provide very much needed river frontage.

However, the fact the park has not met its initial goals of including the Rooipoort and Pniel properties in some form of greater national park (even under some form of contractual agreement) has brought the very existence of the park into question. Recent pressure by the small mining community has called for a reevaluation of the situation (Hall-Martin 1998).

- Proposed population management

Assuming the status quo remains as is and in the light of past fighting, it is recommended that the ECC should be maintained between 0.04 – 0.06 rhino/km² (Knight & Novellie 1995), and with the desire to maximize breeding, the EMPCC should not exceed 9 animals. The number of breeding bulls should be restricted to one (and possibly two), with three or four breeding females and their immediate progeny. Calves in age classes C to D should be translocated to other pop-

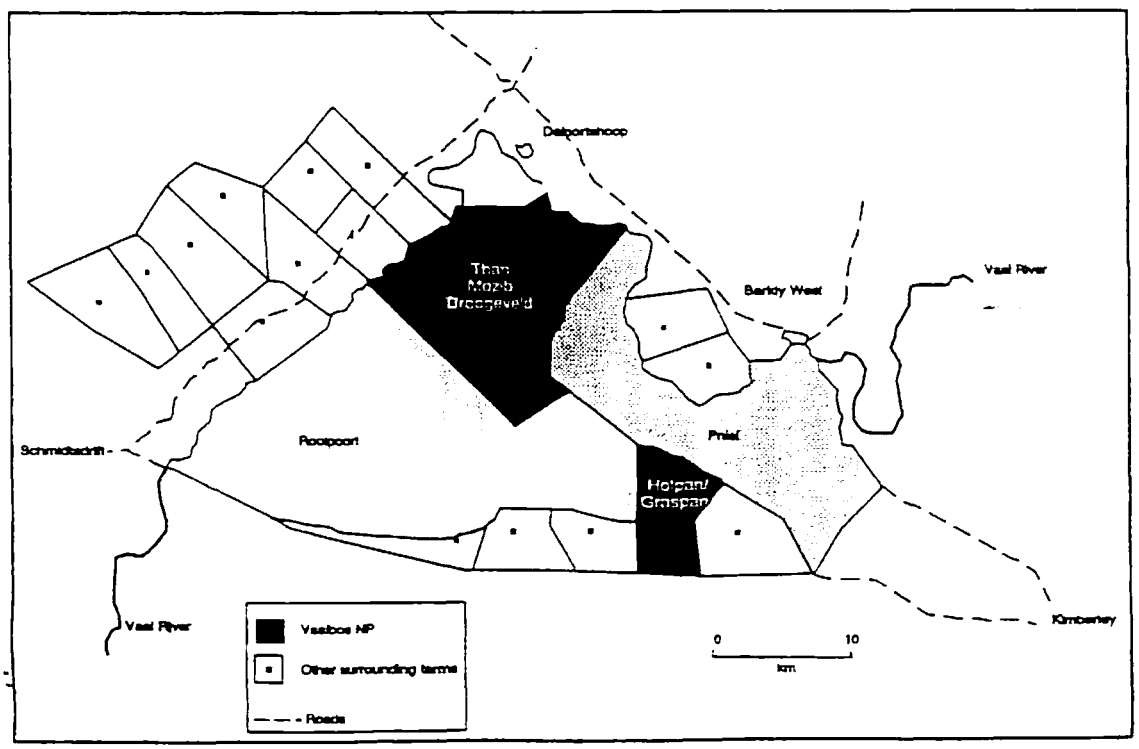

Fig. 5. Vaalbos National Park and surrounding land.

Table 8.

Expected frequency and probability of affect on the reproduction and survival of the *D. b. cf bicornis* populations by three types of catastrophies (poaching, disease and drought)

Park	Poaching			Disease			Drought		
	% freq.	Repr.	Surv.	% freq.	Repr.	Surv.	% freq.	Repr.	Surv.
AFNP	5.0	1.0	0.80	1.0	1.0	0.95	10.0	0.5	0.9
VNP	2.5	1.0	0.80	1.0	1.0	0.95	5.0	0.5	0.9
KRNP	2.5	1.0	0.80	1.0	1.0	0.95	5.0	0.5	0.9
AENP	1.0	1.0	0.80	1.0	1.0	0.95	2.0	1.0	0.9

ulations as a matter of policy to remove any chance of further conflict.

- Monitoring & Security

Owing to the density of the bush in which the animals normally occur, monitoring should consist of a number of approaches:

a. All sightings by ranger staff should be noted for the date, time, position, number and age/sex composition, condition and general behaviour. Ranger staff should regularly track animals down to record their presence. This could be facilitated by the use of a number of well trained trackers.

b. Waterhole watches over full moon noting same as above.

c. Aerial surveys from the helicopter on an annual basis (plus whenever available) which is also used to maintain a photographic record of each animal and calving records.

d. Regular (at least every two months) fixed wing survey noting same as the above.

The security system of the park has not been tested and with its isolation away from any major roads, the threat was considered to be moderate to poor (Knight 1995). This grants no room for complacency as the park does border on a communal land area in the north, albiet on the other side of the Vaal River. Security alertness should be improved with greater patrolling by armed, well trained scouts in the rhinoceros concentration areas and the stationing of personal within the park. All efforts should be made to increase the ranger component of the park as the 1 man/36 km² is not particularly ideal (Knight 1995). Paramilitary refresher coursers should be a part of the annual programme. An information network need also be established as a matter of urgency to pre-empt any attack on the population.

C. Karoo NP population

- Present status

Karoo National Park formed the first satellite population to be established from the Augrabies and Vaalbos founder populations. Knight & Novellie (1993a) suggested that the animals should be introduced into the Doringhoek section rather than the initially proposed Sandrivier section owing to greater altitudinal variation and diversity of vegetation communities (Fig. 6).

Since the introduction of the three animals (1.2) to the 7148 ha Dooringhoek section in late 1993 and early 1994, the population has settled in well concentrating predominantly in the river valley and vegetation on the lower scree slopes. An attempt to introduce another female (Tswaros – 4 yr old) from AWNP was undertaken in October 1994. Using the same introduction protocol implemented in AWNP, the female was introduced into a ca 1900 ha fenced camp, located in the south western corner of the Doringhoek camp. However, the female broke through the unelectrified fence separating the two rhinoceros areas and was subsequently injured by one of the other rhino. Field staff were of the opinion that the adult Ngara II female was the aggressor and not Chipembere the adult male. Tswaros was then captured and safely moved to AENP.

By the end of 1996 one calf (Gamka) had been born into the population, making it the first second generation calf born into the *D. b. bicornis* population in South Africa (Table 6). The birth of this calf has raised the stocking rate to 0.056 rhino/km² which approaches the recommended carrying capacity for this sections of the KRNP (Table 2). (....whereby the SANP has opted to transfer the majority of the *D. b. cf. michaeli* to a local private landowner (under contract), while keeping a smaller breeding nucleus of animals in the KRNP (Knight & Hall-Martin 1998a). The transfer of rhino to the Thaba Tholo Private Game Reserve in theNorthern Province was partially a sale and swop for six *D. b. cf. minor* from KwaZulu-Natal that were free-released in the KNP. The retention of a breeding nucleus of *D. b. cf. michaeli* in the KRNP requires the transfer of the resident *D. b. cf bicornis* to AENP. This whole operation is aimed at making the important AENP valley bushveld available to the historically indigenous *D. b. cf bicornis* sooner than if the SANP had followed the preferable but dragging transfer of animals to East Africa. This option remains part of the

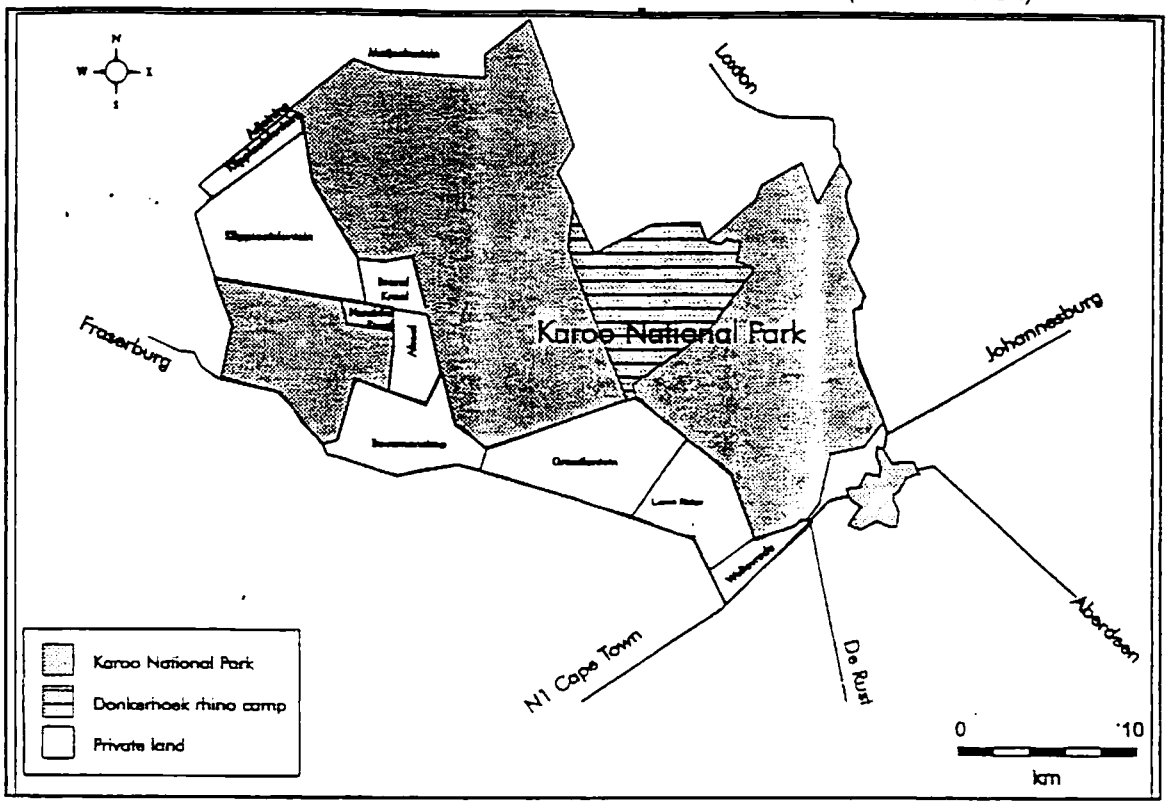

Fig. 6. Karoo National Park and surrounding land proposed for inclusion in the park

contractual agreement drawn up with Thaba Tholo in which no *D. b.* cf *michaeli* are to be sold/loaned/swopped to any other organisation or private individual in South Africa, but that the animals will be preferably made available to East African concerns and reputable zoological gardens. Moreover, the small breeding nucleus of *D. b.* cf *michaeli* destined for the KRNP is part of SANP obligations to hold a sement of the population, particularly the newly introduced animals from Port Lympe and Tanzania to guarentee their breeding.}

D. Addo Elephant NP population - Zuurberg section

- Present status

The reintroduction of this ecotype to the AENP formed part of the SANPs overall policy to re-establish only indigenous species/subspecies/ecotypes in national parks. Notwithstanding the fact that black rhino, continent wide, are endangered, and that the valley bushveld vegetation offers some of the best black rhinoceros habitat in Africa, the SANP felt the conservation of the regionally important *D. b.* cf *bicornis* ecotype should take precedence over the East African *D. b.* cf *michaeli* population already established in the park (Hall-Martin & Knight 1994). However, the removal of the *D. b.* cf *michaeli* animals has proved to be a protracted affair, owing to the lack of in situ sites and the costs (to the recipient) associated with the capture and transfer of the animals. For this reason, there has been a shift in policy whereby the SANP has opted to transfer almost half of the *D. b.* cf *michaeli* population to a local private landowner (under contract), while keeping a smaller breeding nucleus of animals in the KRNP (Knight & Hall-Martin 1998a). The transfer of rhinoceros to the Thaba Tholo Private Game Reserve in the Northern Province was partially a sale and swop for six *D. b.* cf *minor* from KwaZulu-Natal that were free-released in the KNP. The retention of a breeding nucleus of *D. b.* cf *michaeli* in the KRNP requires the transfer of the resident *D. b.* cf *bicornis* to AENP. This whole operation is aimed at making the important AENP valley bushveld available to the historically indigenous *D. b.* cf *bicornis* sooner than if the SANP had followed the preferable but dragging transfer of animals to East Africa. This option remains part of the contractual agreement drawn up with Thaba Tholo in which no *D. b.* cf *michaeli* are to be sold / loaned / swopped to any other organisation or private individual in South Africa, but that the animals will be preferably made available to East African concerns and reputable zoological gardens. Moreover, the small breeding nucleus of *D. b.* cf *michaeli* destined for the KRNP is part of SANP obligations to hold a segment of the population, particularly the newly introduced animals from Port Lympe and Tanzania to guarantee their breeding.

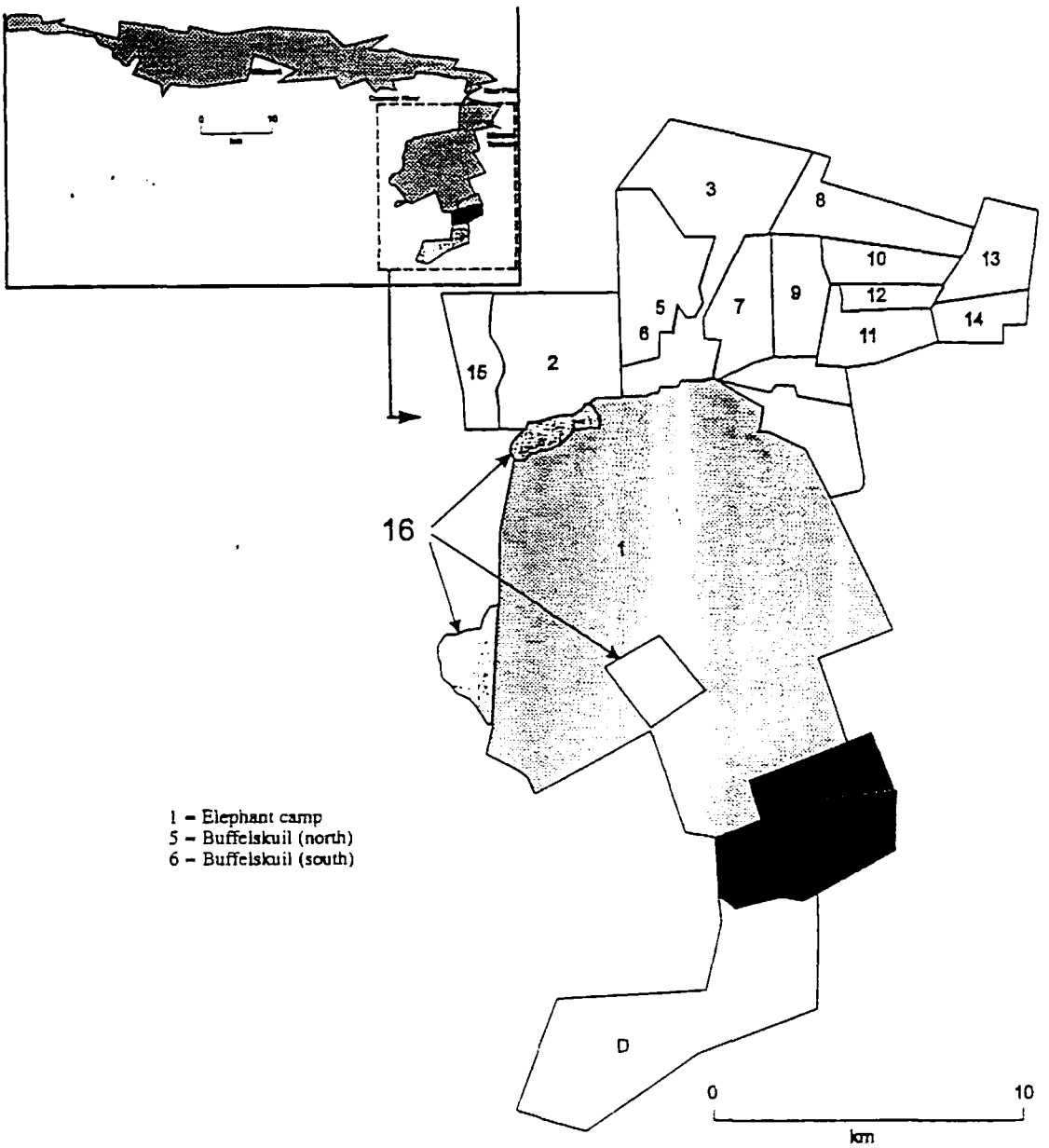

Fig. 7. Addo Elephant National Park with elephant camp and surrounds expanded.

The introduction of the *D. b.* cf *bicornis* ecotype to the AENP has gone through two stages (Table 7). The first included the introduction of Arie (the old bull from AFNP) and two young females into the 5.82 km² Kleinvlak camp situated outside the main elephant camp which holds the *D. b.* cf *michaeli* population. Only about 50% of this camp provided ideal rhinoceros habitat which meant the stocking rate was at 1.03 rhino/km² (Fig. 7), and besides this high density their body condition was considered excellent and there were no overt signs of agression. The three animals remained in Kleinvlak until the 14/6/96 when they were all transferred to the 4.83 km² large (density = 0.62 rhino/km²) northern camp in Buffelskuil (Fig. 7).

Owing to injuries sustained from fighting in VNP, the subadult bull Benji was transferred from VNP bomas in June 1995 and held in the Addo bomas until he unfortunately died of a *Babesia* infection in August 1995. The strain of *Babesia* was thought to have been introduced with the *D. b. michaeli* from Kenya. As a result of this the bomas are now thoroughly disinfected prior to the introduction of any further animals. This proved successful with the introduction of three more rhinoceros (2.1) from VNP in March 1996, who were

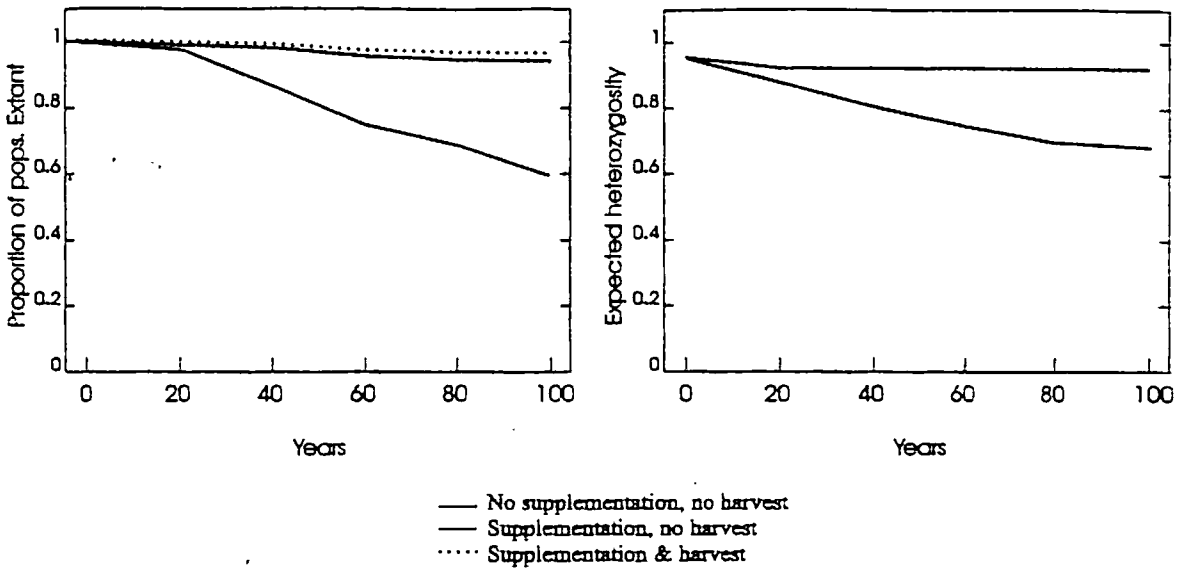

Fig. 9. expected population survival and heterozygosity of the *D. b. bicornis* populations under a metapopulation scenario in which supplementation and harvesting of animals are altered.

1. The frequency of occurrence and effect (on the probability of reproduction and survival) of three types of catastrophies (poaching, disease and drought) were estimated for each population depending upon their expected susceptability (Knight 1995) to these factors as listed in Table 8.
2. Females and males breed at 7 and 10 years of age, respectively.
3. Age of senescence = 35 years.
4. Female reproductive rate = 0.286 births/adult female/year.
5. 30% of adult males breed.
6. Calf (< 4yrs) mortality = ±5%/year.
7. Adult mortality = 2.86%/year.
8. Although four metapopulations were considered, two (VNP and AFNP) were used as the founder populations from which the other populations were stocked. The probability of migration between populations was assummed to be 0.056 and 0.065/adult/year from AFNP and VNP, respectively. These are based upon the rates to date. From AFNP, 10% were to go to VNP, 20% to KRNP and 70% to AENP. From VNP, 10% were to go to AFNP, 20% to KRNP and 70% to AENP. Three scenarios were used as follows:
   - No supplementation, nor harvesting.
   - Supplement each of the four populations with an adult male once every 10 years, and no harvesting.
   - Supplement and harvest an adult male from each population once every 10 years.
10. A total of 100 simulations over a 100 year period was measured.
11. Inbreeding depression was taken at the default rate.

From the simulation models it soon became obvious that without any supplementation nor harvesting, the probability of a proportion of the populations going extinct increased with time (Fig. 9). However, with the supplementation of breeding males on a 10 yearly basis the proportion of extant populations increased from 60% to 86%, and with harvesting also included it increased further to 90%. The overall heterozygosity of the population showed a similar response with an increase from 0.72 to around 0.93 for the supplementation and harvesting options. Thus the larger the founder population the greater the chances of survival and preservation of genetic heterozygosity.

The SANP policy of replacing the extralimital *D. b.* cf *michaeli* population in AENP with the indigenous *D. b.* cf *bicornis* ecotype (Hall-Martin & Knight 1994) was hoped to be completed within a few years with most of the animals being repatriated to East African conservation areas. The SANP had planned to generate sufficient revenue from the transfer of the *D. b.* cf *michaeli* to support its own expansion plans to AENP and purchase of further animals from Namibia if required to do so. However, as the process became rather protracted owing to few foreign donors prepared to take the risk of taking the whole population, the SANP resorted to transferring a number of animals to zoological gardens in exchange for donations to the rhino conservation budget. By November 1997 a total of 12 *D. b.* cf *michaeli* had been removed from the

park with six going to zoological gardens and the remainder to Mkomazi Game Reserve (2.2) and Ngorongoro Conservation Area (0.2) in Tanzania. This unfavourable piecemeal approach distorted the sex ratios in favour of males and was considered unhealthy for the remaining population in the event the SANP was to be left with a remnant population. This resulted in the SANP reconsidering its plans and options. The policy accepted was one of selling12 of the animals to a private land owner (Thaba Tholo Game Reserve) in South Africa, yet retaining a beeding nucleus of *D. b.* cf *michaeli* (Knight & Hall-Martin 1998a). This nucleus which will be held to guarentee the breeding of two males reintroduced into the population. It is planned to transfer these animals to the KRNP so as to make the entire AENP available for the introduced *D. b.* cf *bicornis* population (Knight & Hall-Martin 1998b).

3. Eastern (*D. b.* cf *michaeli*)

- Current status

With no excess rhinoceros at that time available from the Natal reserves, seven *D. b.* cf *michaeli* were introduced into AENP from Kenya between 1961 and 1962 (Hall-Martin & Penzhorn 1977), almost a decade before the introduction began into the KNP. Initial poor management of the founders resulted in the death of three animals from fighting. The animals were initially confined at very high densities of up to 5.2 rhino/km² in a small camp apart from the elephants but in 1977 the rhinoceros were released into the larger (39.5 km²) elephant camp which dropped the density to 0.28 rhino/km². It had been found that densities above ±3.3 rhino/km² appeared to have led to intense aggressive encounters and should therefore not be exceeded. Subsequently, the AENP was expanded in 1982-84 to 79.2 km² and again in 1992 to 95.5 km², which resulted in a stocking rate of 0.34 rhino/km² (Table 8).

From the small founder population size and early losses, the rhinoceros population had increased to 35 (inclusive of a bull imported from England on breeding loan) individuals by 1996 at a high rate of increase of 9.1% per annum, well above that noted for most other rhinoceros populations in southern Africa (Adcock 1995). This phenomenal population increase is more than likely attributable to the availability of nutritious succulent vegetation year round, rain throughout the year and lack of frost.

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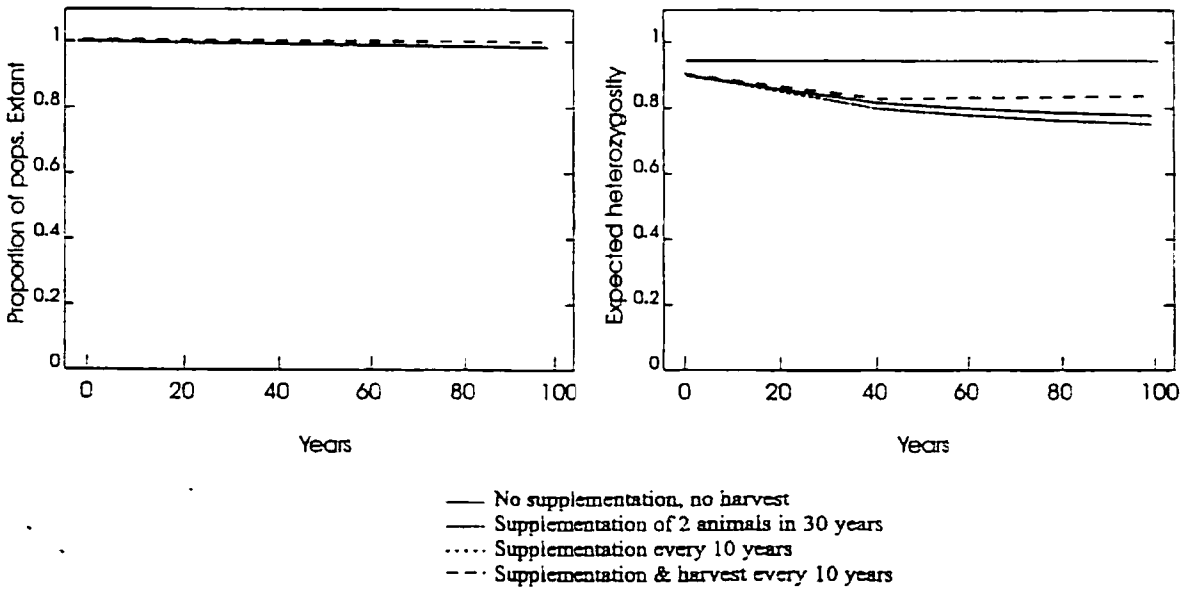
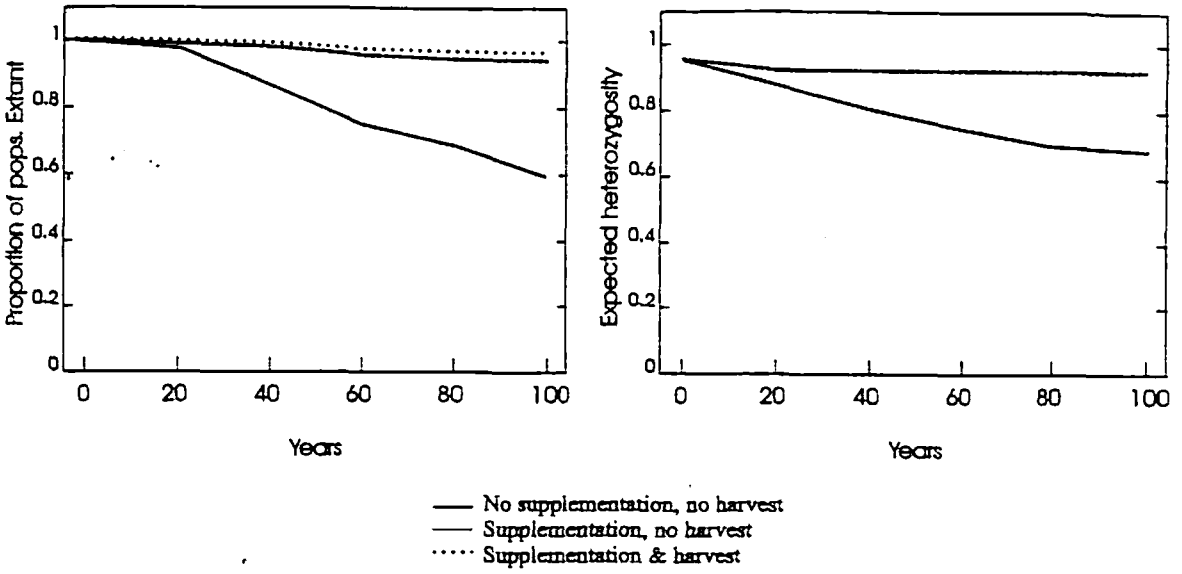


Fig. 10. Expected population survival and heterozygosity of the *D.b. michaeli* population under different supplementation and harvesting rates.



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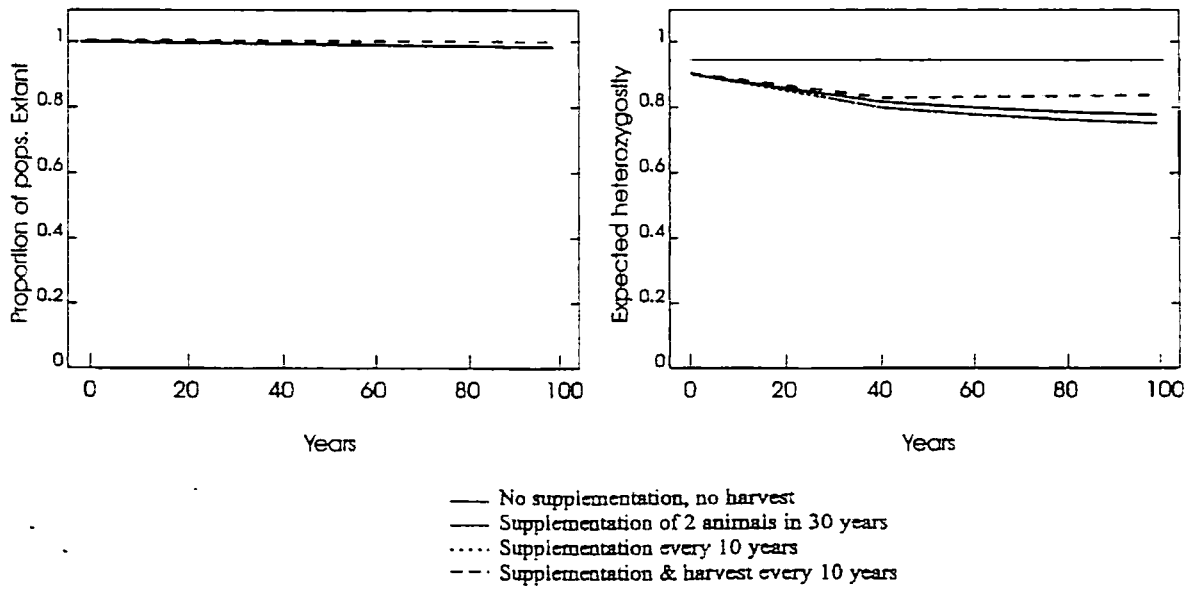

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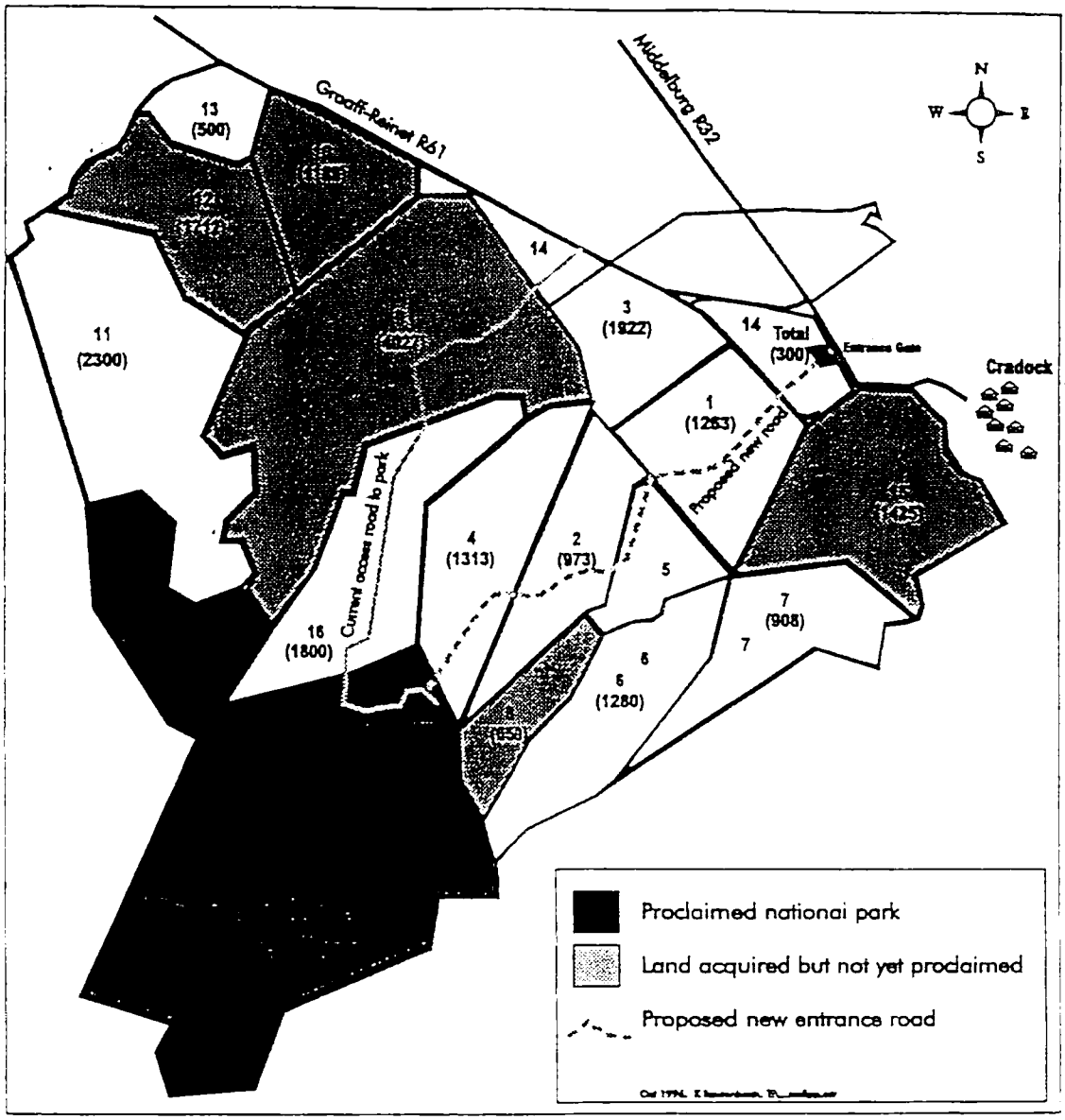

Fig. 12. Mountain Zebra National Park and proposed expansion areas.

respectively. Droughts were considered to have a higher (2%) probability of occurring with a 0% and 10% negative affect on reproduction and survival, respectively.

2. Females and males breed at 7 and 10 years of age, respectively.
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From Figure 10 very little difference in the probability of the populations surviving under the above four different supplementation and harvesting scenarios were noted. Between 0.99 and 1.0 of the simulations survived. This probably arises from the very high calf and adult survival rates which more than likely arises from the ideal habitat and environmental conditions on offer in Addo. However, the expected genetic heterozygosity between between the scenario of no supplementation and harvesting and the introduction of two males produced similarly low heterozygosity values of between 0.75-0.77 after 100 years. Only with an increase in the supplementation and harvesting rate did the heterozygosity increase to 0.83. But this still falls short of the minimum desired heterozygosity value of 0.90. This could only be increased by effectively increasing the founder population size through greater supplementation. One point that emerges from these simulations is the importance of harvesting on increasing the genetic heteozygosity as it allows a greater number of males to reproduce in this small population.

Other parks capable of carrying black rhino

1. West Coast National Park

An assessment of the WCNP ability to carry black rhinoceros exposed a number of potential problems (Knight & Novellie 1993b). Although the park is relatively large (270 km²) offering substantial browse it was felt that the food quality on offer (with the exception of the guano-rich deposits on the Posberg peninsula) may be rather wanting given the poor nutrient status of the soils, characteristic of the western Cape coastal plains. In addition the unresolved legal status of the provincial road through the central section of the park was felt to create a problem with respect to management. In the light of these problems it was recommended that the WCNP could be intially tested for its suitability to carry rhinoceros through the introduction of surplus bulls from the other subpopulations. A situation has arisen in the managemenmt of smaller populations that there is definitely a bull carrying capacity which in turn has resulted in the need to keep the sex ratio heavily skewed in favour of females.

With this rationale accepted the recommended ECC for the park should be between 0.05-0.07 rhino/km². The entire park could theoretically carry between 14 - 19 animals. As the park is not entirely fenced it was recommended that the rhinoceros should be introduced into separate fenced camps (Knight & Bezuidenhout *in prep.*). This would be considered a temporary measure until such time as the park is entirely fenced and an agreement has been made with respect to the provincial road.

The availability of fresh drinking water and the need for security makes Abrahamskraal the best site for such an introduction/holding camps (Fig.11). It was recommended that the camps should be about 400 ha each and span across the dunes to provide the greatest amount of habitat heterogeneity as possible. Food would need to be supplemented during this introduction phase and their feeding behaviour and condition closely monitored.

In the event the provincial road can not be controlled it may be advisable to fence-off the southern half of the park for the rhino. This area on its own could carry about eight animals. Little is known of the behavioural consequences of stocking bulls on their own and will need to be closely monitored.

2. Mountain Zebra National Park

Although this park with its karoid vegetation offers suitable habitat for black rhino, it is considered too small (65 km²) at this stage for any introductions. There are however plans to expand the park to around 246.5 km² through the purchase of the additional land (Fig.12). To date, the farms de Rust and Bossieskloof have been acquired and the municipal ground (Sondagshoek) has been donated bringing the extra land to 143.1 km².

At the recommended ECC of 0.05-0.07 rhino/km² the proposed park would be able to carry a maximum of 12 to 17 animals, with an EMPCC of between 9 to 12 animals. This like the Vaalbos and Augrabies populations would not represent a viable population on its own but would have to fit into the metapopulation management strategy with the other parks. If a total of about 8-10 animals (one adult male, three adult females and their immediate progeny) were considered an appropriate size to work with, rhinoceros should theoretically not be introduced into the park until it approaches 190 km². However, in the mean time the park could possibly be used as a bull sanctuary for any surplus bulls unable to be accommodated in WCNP or the Zuurberg section of AENP.

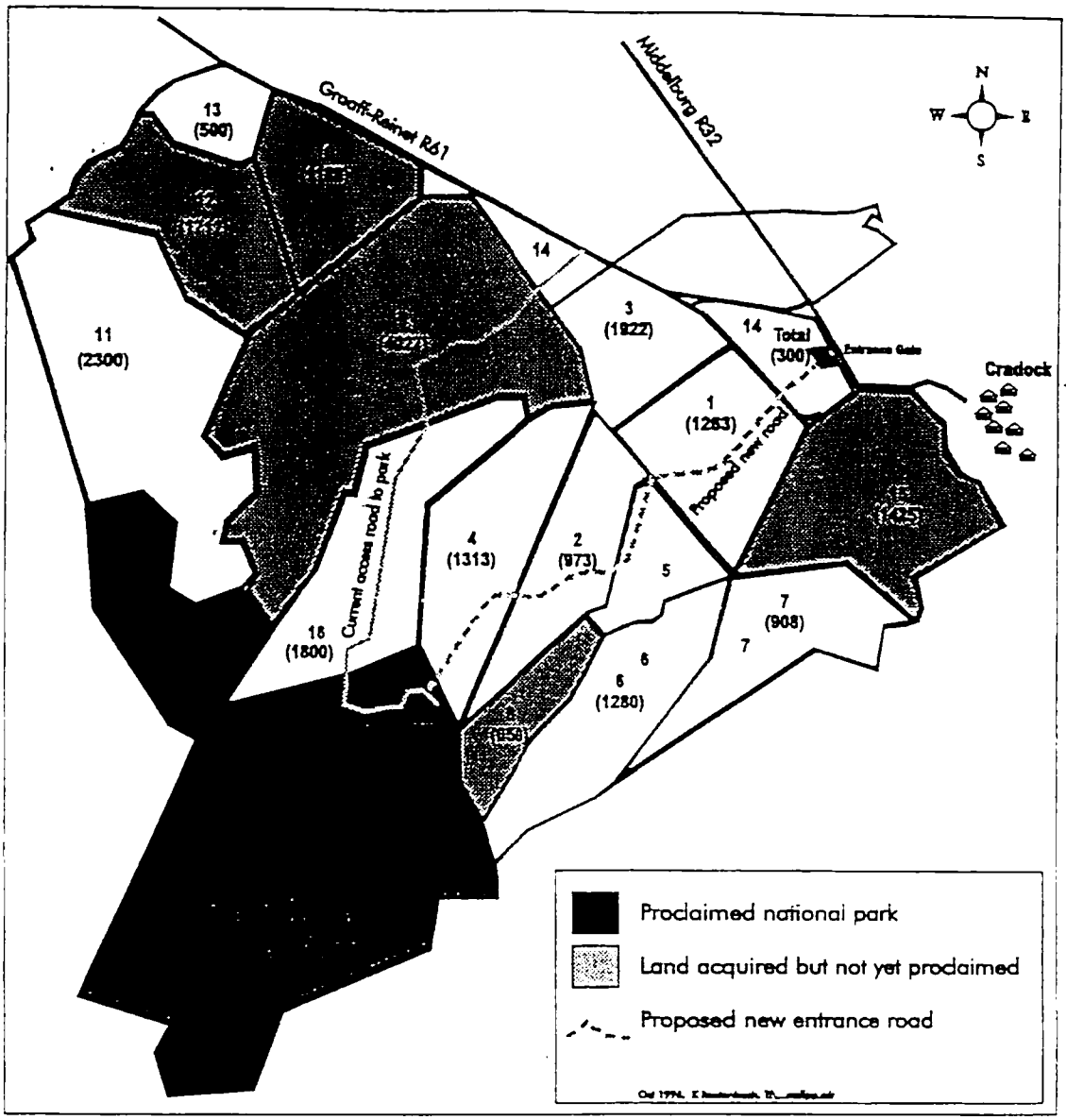

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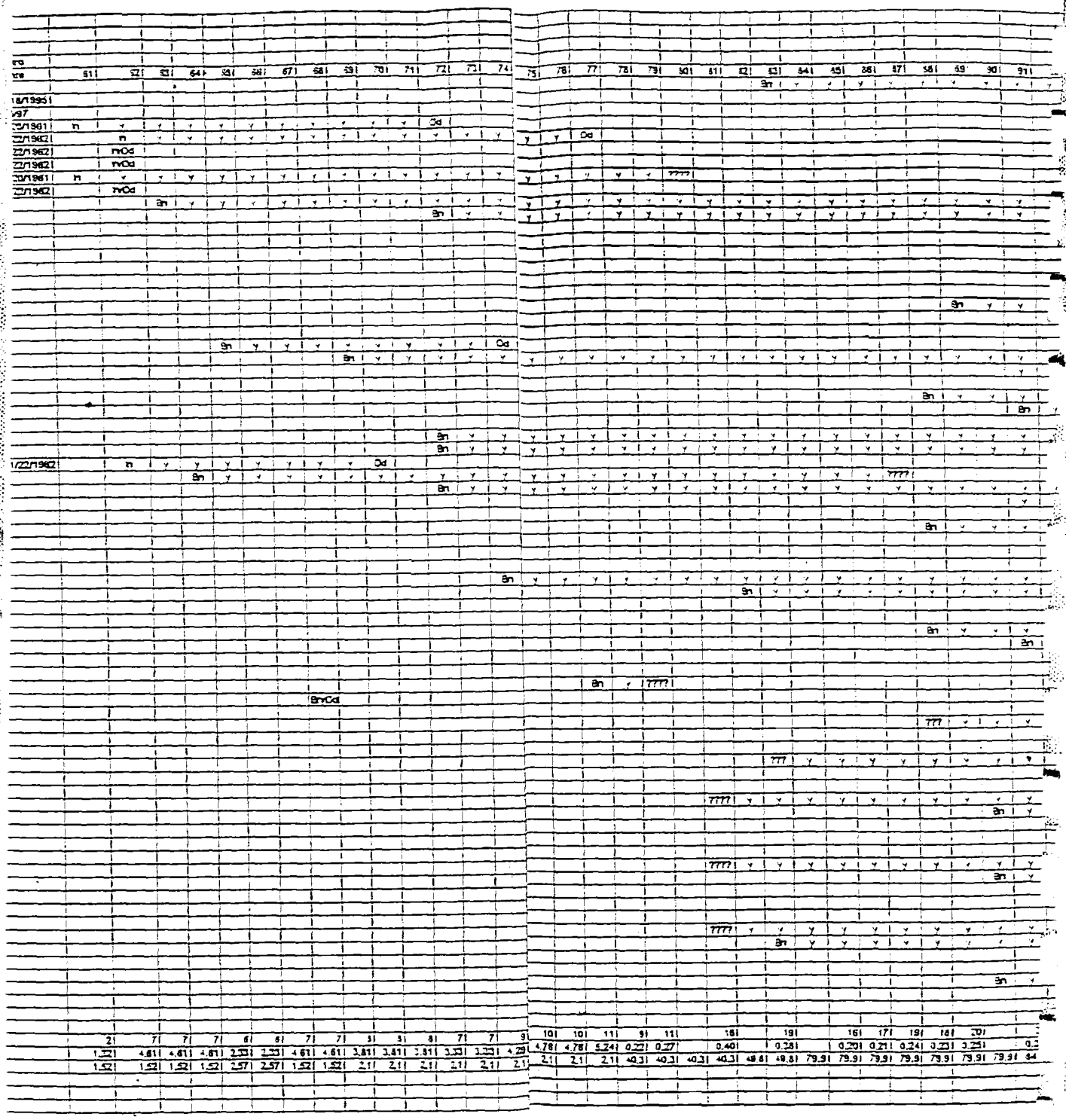
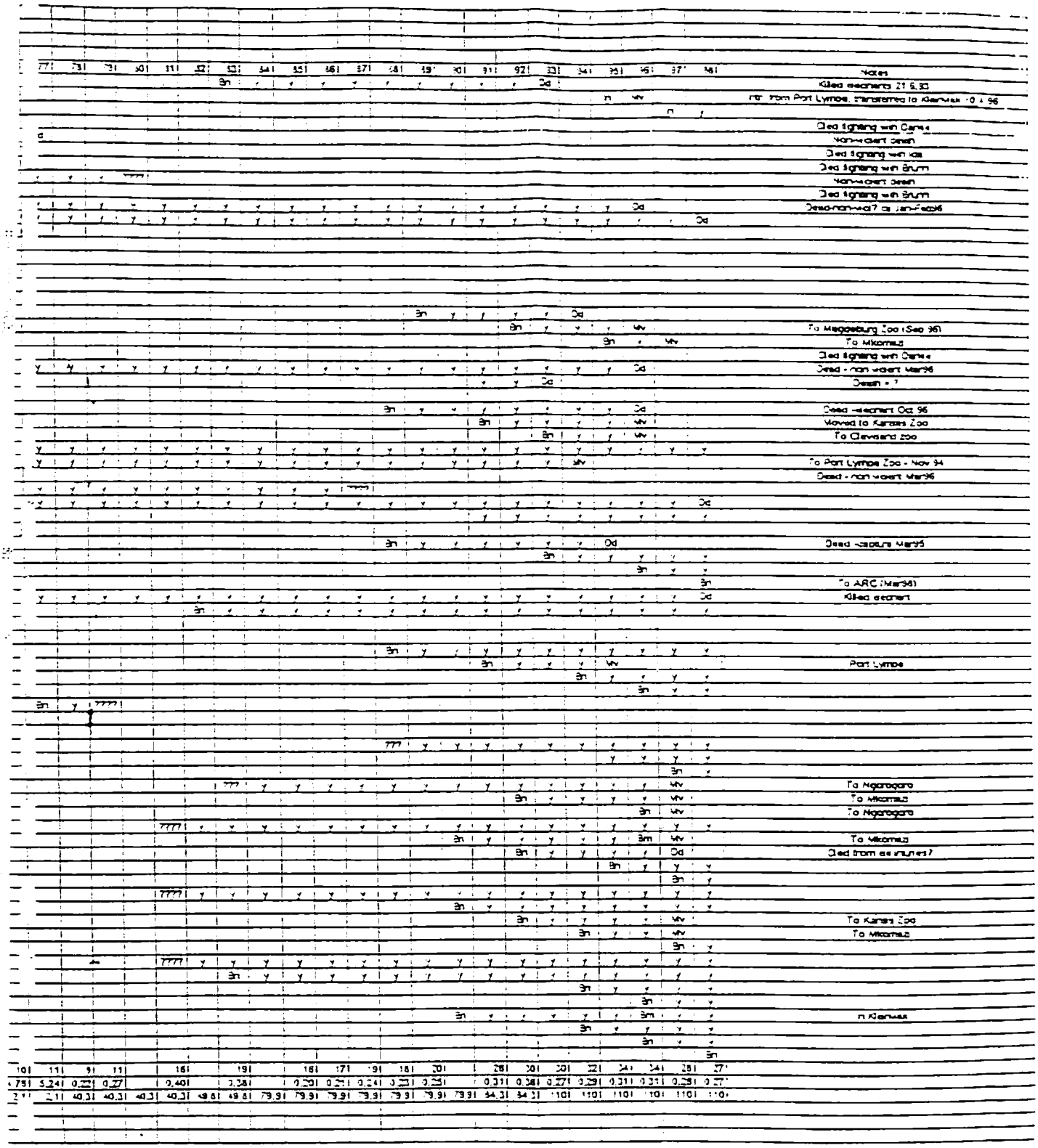
Table 9. History of the O.B. inbred population in the Addo Elephant National park.

Intro. rhino	1st gen	2nd gen	3rd gen	Sex	Born	Dams	Intro date	51	52	53	54	55	56	57	58	59	70
L1				m	06/30/1963	??											
Mbovana				m	soor 66	??	08/18/1995										
Richard				m		??	10/97										
J.A.				m	?	??	03/20/1961	m	y	y	y	y	y	y	y	y	y
Dankie				m	?	??	01/22/1962		m	y	y	y	y	y	y	y	y
Christopher				m	soor 56	??	01/22/1962		m/Od								
Jenny				f	?	??	01/22/1962		m/Od								
BRUNNI				f	?	??	03/20/1961	m	y	y	y	y	y	y	y	y	y
	Marty			f	06/15/1957	Brumi	01/22/1962		m/Od								
	Lucky star			f	39/06/1963	Brumi				3m	y	y	y	y	y	y	y
		Rosenbloem		m	02/07/1972	Lucky Star											
		??			soor ??												
		??			soor 79												
		??			soor 81												
		??			soor 83												
		??			soor 85												
		??			soor 87												
		Tandi		f	04/15/1969	Lucky Star											
		Madiba		m	06/15/1982	Lucky Star											
		Smeil		m	02/15/1995	Lucky Star											
	Klein Jack			m	12/15/1965	Brumi						8m	y	y	y	y	y
	Blom			f	06/15/1968	Brumi										8m	y
		R3		m	01/15/1983	Blom											
		?															
		Zincan		m	03/15/1988	Blom											
		Lucy		f	01/15/1992	Blom											
		Inge 93		f	01/15/1994	Blom											
	Jack			m	10/29/1972	Brumi											
	Gareth Edwards			m	02/07/1975	Brumi											y
RDA				f	?	?	01/22/1962		m	y	y	y	y	y	y	y	3d
	Doreen			f	03/25/1964	ida					8m	y	y	y	y	y	y
		Klein ida		f	03/16/1972	Doreen											
			R1	m	12/15/1982	ida											
			??														
			Toowmd R	f	06/15/1988	Klein ida											
			Zunisse	m	01/15/1993	Klein ida											
			Clara	f	02/15/1996	Klein ida											
			Seeper	m	02/15/98	Klein ida											
	Sidney			f	12/28/1974	Doreen											
		R2		m	12/15/1982	Sidney											
		??															
		??															
		Poopewel		m	06/15/1988	Sidney											
		Vuyo		f	05/15/1991	Sidney											
		Simon		m	02/15/1994	Sidney											
		Hazel		f	10/15/96	Sidney											
	Vosies			f	05/21/1977	Doreen											
A4				f	01/27/1968	ida									8m/Od		
A6				m	01/20/1970	ida											
		Goran		f	?												
			Anna	f	02/15/1995	Goran											
			977	?	02/15/97	Goran											
		Phantom II		f	?												
			Lomu	m	02/15/1992	Phantom II											
			Thandi	?	03/15/1996	Phantom II											
		Phantom I		f	?												
			Piers	f	08/15/1990	Phantom I											
			Jocelle	m	06/15/1992	Phantom I											
			Benjamin	m	01/15/1995	Phantom I											
			97fem	f	02/15/97	Phantom I											
		Kate		f	?												
			Kelvin	f	03/15/1990	Kate											
			Lovina	f	04/15/1992	Kate											
			Rose	f	04/15/1994	Kate											
			Kiara	m	??/97	Kate											
	Vega			f	?												
		Vegan		f	02/15/1983	Vega											
			Mike	m	01/15/1994	Vegan											
			Marusa	m	12/15/1995	Vegan											
		Liza 77		f	09/15/1990	Vega											
		Dou		m	01/15/1994	Vega											
		Coerney		f	02/15/1996	Vega											
		98fem		f	01/15/97	Vega											
Total								2	7	7	7	6	6	7	7	6	6
Density (Am/2)								1.32	4.61	4.61	4.61	2.33	2.33	4.61	4.61	3.81	3.81
Area (km2)								1.52	1.52	1.52	1.52	2.57	2.57	1.52	1.52	2.1	2.1
C:\addocs\rhino\rhino1.wq1																	





Malaka	m	Tshukudu Jan94								Bn	✓	Mv			To AENP 2/96
Dulu	m	Ubeghan Jan95									Bn	Dd			
Vital	m	FaruOct95								Bn	✓	✓	✓	✓	
Mozb	m	Nkhomba Jan96									Bn	✓	✓	✓	
??	M	Tshukudu Apr96										Bn	✓	✓	
??	M	Ubeghan Jan97											Bn	✓	
Total No.			6	6	7	10	9	12	13	11	11	8	9	10	
Density (km²)			0.03	0.03	0.04	0.06	0.05	0.07	0.07	0.06	0.06	0.04	0.05	0.06	