CHAPTER 6

MANAGEMENT RECOMMENDATIONS

Veld management

Conservation of "natural areas" are often associated with non or minimal human intervention (Lajeunesse *et al* 1995). Although this may be possible to some extend in huge open conservation areas, small enclosed areas require intervention at certain levels to ensure achievement of objectives.

Two strategies in applied ecology can be identified; deferred action type, which implies that no management can be applied until a system is fully researched and understood, and the adaptive management type, which is management through a process of learning, a "trail and error" - approach (Mentis 1980). Last-mentioned approach has been suggested by several wildlife managers and ecologists as being appropriated in wildlife reserves and game ranches (Pauw 1988; Stuart-Hill 1988; Smith 1992). To qualify and quantify the impact of a management action on the system in order to evaluate the effectiveness thereof, a monitoring system aimed at detecting the rate and direction of change at an appropriate level need to be in place.

The rate and direction of plant succession can be influenced through management in three ways (Lajeunesse *et al* 1995):

- Accelerating natural succession
- Inhibiting the process
- Allowing natural succession to take place (nonintervention option)

These three options will be applied at different levels of ecosystem management in Rustenburg Nature Reserve to achieve specified objectives.

A park manager's influence on the vegetation composition and structure is generally very limited and confined to control over the fire regime and the type and numbers of herbivores (Scholes & Walker 1993). Other more drastic management intervention measures to be applied includes selective or non-selective removal of woody plants to achieve open grassland, active rehabilitation of disturb or denuded areas, active removal and treatment of alien plants and mowing of grassland to reduce vigour or to remove moribund material.

The elements impacting on runoff are best expressed through the water balance (Bosch *et al* 1984):

$$P = (T + I + E_{s+w}) + Q + S$$

where

P = gross precipitation
T = transpiration
I = interception
E_{s+w} = evaporation from soil and water surface
Q = stream flow
S = change in soil moisture storage

and

$$Q \text{ (stream flow)} = P - (T + I + E_{s+w}) - S$$

Figure 44 is a systems representation of the hydrological cycle at catchment level (Wicht 1971).

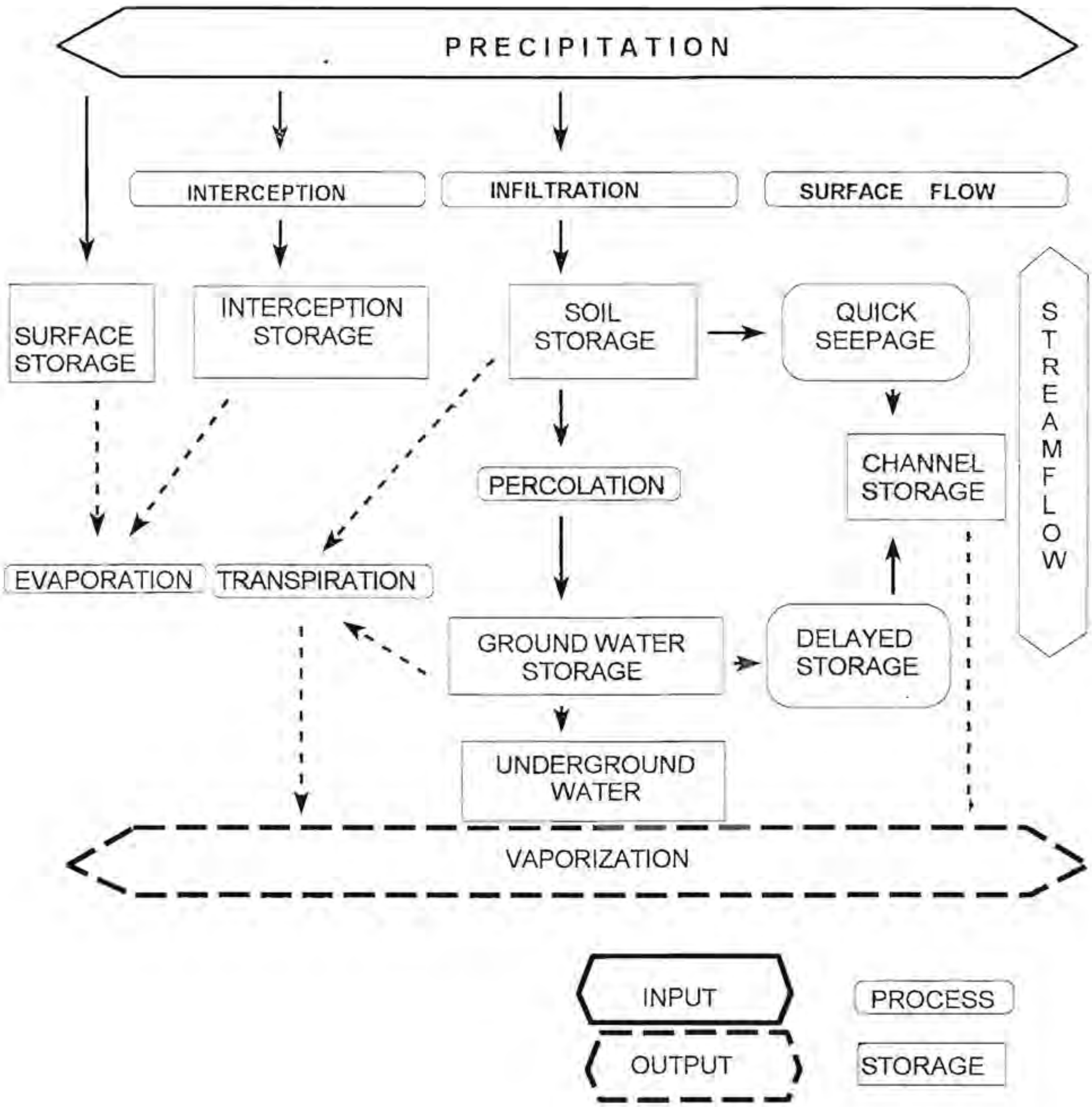


Figure 44: A systems representation of the hydrological cycle at catchment level (Wicht 1971)

As little can be done to effect the gross precipitation, management actions must focus on reducing transpiration, interception, evapotranspiration and changes in soil moisture storage. Transpiration can be reduced by removing or reducing the canopy, which will have other obvious negative impacts, i.e. increased run-off speed with increased risk of erosion and its associated impacts. It does however require the removal of alien vegetation with high water requirements, i.e. *Eucalyptus, Jacaranda, Salix babylonica* and *Populus*.

Precipitation is intercepted by canopy cover and directly returned to the atmosphere through evaporation (Bosch *et al* 1984). Studies in the Western Cape indicated the gross interception loss in a *Pinus radiata* plantation to average 30% of rainfall (Versfeld 1978) in Bosch *et al* 1984). Schulze (1980) calculated values for potential interception losses:

Veld type	Interception loss ($mm.day^{-1}$)
Indigenous forest	+ 3,2
Bush veld and Savanna	1.6 - 4.4
Fynbos	0.8 - 2.0
Grassland	1.2 - 2.6

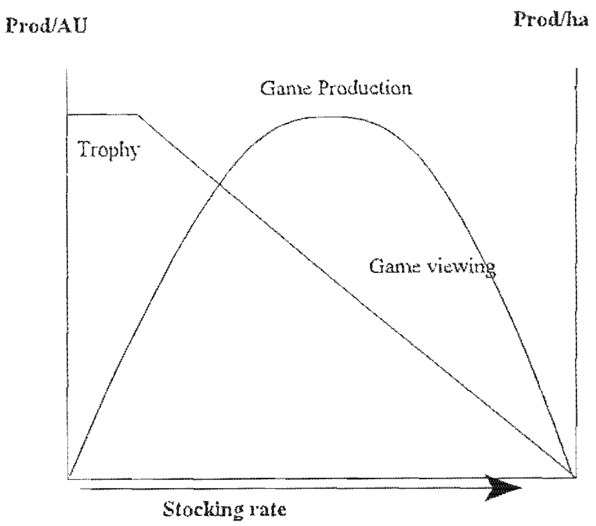
Fire and herbivory will reduce interception losses, but the magnitude of the effect will depend on a number of factors, i.e. post-fire recovery (Bosch *et al* 1984) and the long term effect of frequent fires and intensive herbivory on vegetation composition and structure.

Water infiltration into soil depends on surface factors, such as initial wetness, texture and structure, cover, topographical features and other physical characteristics of the soil profile (Bosch *et al* 1984). Factors such as structure, organic content and cover can be manipulated to some extend through management to improve or reduce water infiltration. By reducing the vegetation cover or organic content of the soil through an indiscriminate burning programme (very intense or frequent fires) or intensive herbivory, the structure and therefore water retention capabilities of the soil will be reduced, which results in increased runoff speeds and a decrease in the rate of water absorption. It can also increases soil evaporation, since the shading effect of vegetation is no longer present and net radiation increases (Bosch *et al* 1984).

The management of the vegetation on Rustenburg will be aimed at maintaining a high canopy and basal cover in order to ensure high infiltration and percolation rate. Within this limitation, it will also be managed to obtain a high plant species diversity and reduced erosion.

GAME MANAGEMENT AND STOCKING RATE

The stocking rate of different game species in an enclosed park or nature reserve is determined by the type and condition of the different available habitats as well as the management objectives for the ranch (Trollope 1990). It must primarily be a function of the grazing and browsing capacity of the veld, which in turn depends on veld condition.



The relation of production of animals against stocking rate

The stocking rate of game should vary in accordance to the management objectives of the reserve (Thompson 1986; Bothma 1989). Stocking rate can be expressed as a percentage of the ecological carrying capacity (ECC). The ECC is the maximum population of animapls that an area can support without deterioration of the habitat (Thompson 1986; Bothma 1989). For maximum venison or animal production it is recommended that the stocking rate should be between 50 and 75% of the Ecological Carrying Capacity (See figure). At this level the rate of increase of an animal population is at its maximum. For trophy hunting, the stocking rate should be below 50% of the ECC, since, at this level, the environmental influences, such as forage is at an optimum for animal performance (Trollope 1990). Conversely for sport hunting and game viewing as is the situation on Rustenburg Nature Reserve, the stocking rate should be higher than the maximum rate of increase, because here the emphasis of management is on maximizing animal numbers within the limitations of catchment conservation (Trollope 1990).

The objectives for the introduction and management of game on the reserve is :

- To be used as a tool in the management of the vegetation structure and composition
- to increase the numbers of the game currently on the reserve to levels where they can be used on a sustainable basis. Given the realities of shrinking government support, pressure on optimising income from natural resources is increasing. To improve the visitor's experience to the reserve, it is envisaged to improve game viewing in the reserve by optimizing the number and diversity of game in the park, especially the highly visible species suitable to this environment such as sable antelope and waterbuck (*Kobus ellipsiprymnus*). Further introductions should be considered against their role in the achievement of reserves goals and objectives.
- where feasible, to breed endangered and valuable species, i.e. sable antelope and roan antelope.

Initial carrying capacity estimates can only be used as a guideline. Changes in veld condition as a result of variable rainfall and management affect carrying capacity of the veld continuously. Rainfall is considered a determining factor in the production of the herbaceous layer in the arid and semi-arid areas, and as carrying capacity is closely related to rainfall , it should be adjusted annually. The principle of adaptive management, which will be applied in the management of Rustenburg Nature Reserve, require continuous evaluation and adjustment of management strategies as their impact on the system become evident. This principle will also be applied in the management of game and in the refinement of the stocking rate of the game. The impact of herbivory on cover and structure of the vegetation will be evaluated against the primary goal of catchment conservation and management. The rate and direction of change of monitoring sites along a degradation gradient will dictate the impact of current stocking levels on veld condition.

Optimal production of key animal species

If the general effect of stocking rate on animal performance is considered(Jones & Sandland 1974), it is clear that, at low stocking rates production per animal unit is at maximum. After a certain period, when competition for forage occurs, production per animal unit decreases linearly to zero.

Conversely, at low stocking rates animal production per hectare is low, but increases with an increase in stocking rate until it reaches a maximum after which animal performance decreases to zero. If the objective of management is to maximize production per animal unit (as in trophy hunting) a low stocking rate should be applied. If the emphasis is on venison production, a stocking rate should be applied that will maximize production per hectare.

Fairall (1985) constructed a population simulation model using biological data from wild populations of impala to illustrate the effect of sex and age ratio manipulation on productivity. A model population of 1000 animals was assumed to be the economic carrying capacity of the environment and the population growth rate was seen to be 13%. When the sex ratio was changed from 1♂:3♀ to 1♂: 10♀, productivity was shown to increase by 30%. If all individuals older than three years were harvested, an increase of 138% was achieved. It must however be stressed that this model is only applicable to impala.

The following are principles regarding optimal production:

* Non-productive excess animals must be removed
* Skewed sex ratios can have a negative influences on production
* Competition between animals for food and space should be minimized if they are expected to perform optimally
* Production per hectare is reduced if all potential habitat is not in healthy state

Mentis (1981) classified ruminant and non-ruminant ungulates according to their relative potential for defoliation and selective grazing:

- ♦ Bulk grazers: large animals which normally do not exercise a high degree of selection, i.e. zebra, waterbuck, buffalo and cattle.
- ♦ Concentrate/Selective grazers : Small animals which are predominantly grazers, i.e. springbuck, red hartebeest, roan antelope, sable antelope and oribi
- ♦ Mixed feeders: Animals that feeds both on grass and brows, pods, leaves, forbs, i.e. eland, impala
- ♦ Browsers: Animals that feed mostly on leaves, flowers, pods and fruits, i.e. kudu, bushbuck.

Mentis & Duke (1976), and Mentis (1977) suggest that the metabolic mass of concentrate grazers should not be permitted to exceed that of bulk grazers in any grazing unit.

Collinson & Goodman (1982) classified herbivores in Types 1 to 4 according to their impact on their habitat, their ability to change their habitat and the effects the change have on other species:

- Type 1: Animals that affect significant changes in the structure and composition of their habitat; i.e elephant, zebra and buffalo
- Type 2: Animals that tend to decrease because of the impact of Type 1 and Type 3 animals on their habitat. These are generally low density species that are negatively affected by competition, i.e. roan antelope, sable antelope and tsessebe
- Type 3: Animals that increase as a direct result of the impact that type 1 species have on their environment. These are species such as red hartebeest, springbuck, impala and oribi
- Type 4: Game species that increase in numbers because of the effect of Type 1 & 3 animals, i.e Kudu, Giraffe

Current performance of important game species and general discussions

Introduction

Game were introduced into the reserve in the early seventies. Various game census techniques, ranging from drive counts to modified road strip counts were applied. The data, collated in the game register, is very inconsistent and trends are difficult to distinguish and explain. During the analyses of the data, the need for a standardized, repeatable census technique become evident. A standardized census technique for Rustenburg Nature Reserve was developed in this study and is described later in the chapter. It was implemented in 1995. Count results have since improved and comparisons between data sets are now possible.

Game numbers collected through annual censusses were analysed to provide an indication of trends in the different game populations in the reserve. These trends provide the basis for future management of the various populations.
During the analysis of the count data on the reserve since 1985, two procedures

to determined the rate of growth in game populations were applied to the data sets. These procedures were used to "smooth - out" fluctuations between successive counts, due to inconsistent counting techniques and human error. These two procedures produced growth curves, which when applied to the data sets gives an indication of fit to the actual data, and also future responses and growth in the population

The finite growth rate - the growth in a population between successive counts - is determined by the following formula (Bothma 1995):

$$\lambda = (N_{t+1})/N_t$$

where	λ	=	finite rate of growth
	N_t	=	Population size in year t
	N_{t+1}	=	Population size in year t+1

The exponential growth rate can be used to determined the average growth rate in a population where annual fluctuations is significant as a result of changing environmental factors or count results (Bothma 1995). The exponential growth rate is calculated as follows:

$$r = \frac{\Sigma Nt - (\Sigma N)\Sigma t/n}{\Sigma t^2 - (\Sigma t)^2/n}$$

where	r	=	average exponential growth rate
	N	=	natural logarithm (base e) of each count
	t	=	time
	Σ	=	sum of
	n	=	number of counts

These two formulas were applied to the data and growth curves were produced, which, when fitted to the actual counts, provided an indication of population response and trends.

Discussion

Sable antelope have been classified as type II herbivores (Collinson & Goodman 1982). Rustenburg Nature Reserve provide adequate habitat for sable antelope, provided protein and phosphorous deficiencies are addressed (Wilson 1975). Sable antelope were introduced into the reserve in 1967 (Wilson 1975). Twelve animals were brought into the reserve and the population increased very slowly initially. The proportions of juveniles seen annually were higher to the proportion of yearlings. However, the number of adults, especially cows remained constant. Wilson (1975) suggested a high mortality rate amongst this sex and age class, although no carcasses could be found.

The actual counts of the sable antelope population in the reserve since 1985 indicates an average finite growth of 8.9%, and a exponential growth rate of 6.47% over the 15 year period (Figure 45). The actual count figures over this period also indicate a distinct period between 1990 and 1995 where the population trend suddenly stabilized between 36 and 42 animals. The count for 1993 (n = 53) does not fit the population trend, due to sampling error and human factor. From 1996 the growth in the sable antelope population resumed at an increased rate of 17.9%. In 1996 a strategy was adopted to apply control burns at the end of the growing season. (See Burning program). The rationale for applying late summer burns was to ensure green flush during winter. Estes (1990) indicated that green plants, forbs and foliage makes up 20% of their diet. Forage quality is dependant on the removal of tall, dormant leave material within a month after the rains end (Estes 1990). Observations by park staff (Crowther[9] & Goosen[10] *pers comm*) indicated that the sable antelope used these burned areas extensively during the dormant season.

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9 Michael Crowther, Former warden, Rustenburg Nature Reserve, currently Pilanesberg National Park, North West Province

10 Magda Goosen, Warden, Rustenburg Nature Reserve

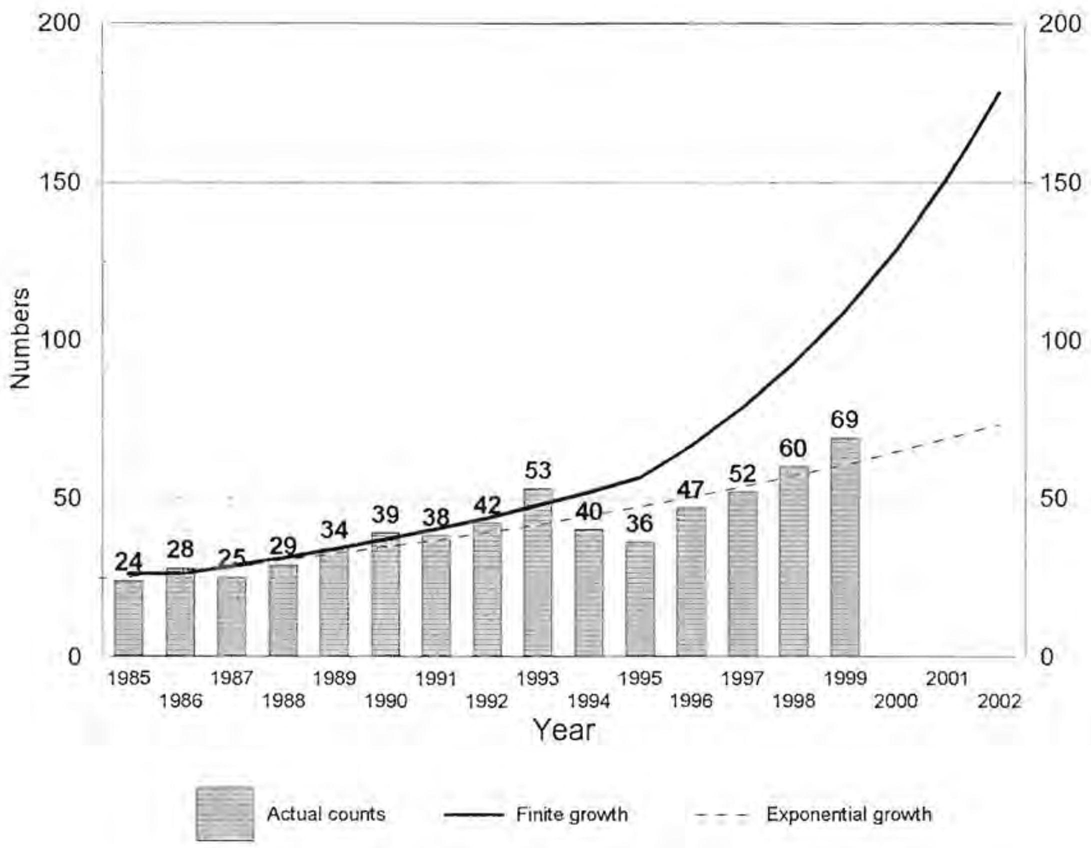

Figure 45: The trend in the population of sable antelope on Rustenburg Nature Reserve since 1985

Natural salt blocks were placed out for the use by the sable. Sable antelope uses salt regularly (Estes 1990). Calf survival rates increased significantly. At the current finite growth rate the sable population will reach a 100 animals in 2002. Sable antelope is very sensitive to competition from other species (Wilson 1975), especially zebra (Grobler 1974) and waterbuck (Du Toit 1992). They favour a mosaic of open woodland and medium to tall grassland, in the mid-succession to climax stage(Estes 1990). These species compete directly with sable antelope and their numbers should be controlled at levels where they do not adversely affect the performance of the sable antelope population. The habitat requirements for sable antelope, and the management of their preferred habitat are compatible with the vegetation objectives of the reserve, *viz.* the maintenance of a resilient ecosystem inside the reserve, capable of enduring excessive runoff and maximise absorption of water. The sable antelope population should be managed at approximately 75% of ecological carrying capacity. It is recommended that removals only be considered once the sable antelope number on the reserve has passed this level significantly and a sufficiently sized group animals can be removed at once. As a conservation organization, the North West Parks & Tourism Board should encourage founder groups of these animals of adequate size (~ 15+) to be introduced into areas where they do not occur.

Impala are predominantly grazers while the nutritional quality and palatability of grasses are still at acceptable levels (Estes 1990; Pietersen *et al* 1993; Brown 1997). In the winter months and during droughts they will revert back to browse. (Dunham 1981). Atwell & Bhika (1985) found that impala meet the requirements of an optimal forager, as its dietary range of reflects selection for high protein components. Studies by Beardall *et al* (1984) in Kruger National Park indicated that they prefer the lower lying areas along drainage lines, with short grass and generally more trampled and disturbed, under an open woodland (Estes 1990). A further important feature is the indication of an ecological segregation between impala and zebra (Beardall *et al* 1984). This segregation was also found by Dekker *et al* (1996) in a study in the Northern Province of South Africa. The situation on Rustenburg Nature Reserve confirm this finding. Impala are mainly found on the edges of the *Becium obovatum - Protea caffra* Tall Closed

Woodland in the central basin, and in the open areas in the south easterly valleys. The population in the reserve has stabilized despite removals (Figure 46). However, the accuracy of the aerial census for estimating impala numbers is unknown, as is the precision. Aerial counts have the disadvantage that relative inconspicuous animals are difficult to locate from the air, especially in densely wooded areas (Collinson 1985). Counts must be replicated to detect variances between the counts (Reilly *et al* 1998).

Eland are classified as mixed grazers (Buys 1990), selecting only high quality food. They use grasses only when young, but revert back to browsing when the nutritional quality of the grass decreases in the winter months (Melton & Snyman 1989). This is also evident in Rustenburg Nature Reserve. Newbery (*pers.comm*)[11] observed eland causing extensive damage to the trees and shrubs in the *Becium obovatum - Protea caffra* Tall Closed Woodland during the winter months. In Rustenburg Nature Reserve they were observed browsing on woody plants such as *Acacia caffra, Ziziphus mucronata* and *Diospyros lycioides* (Newbery (*pers.comm*); personal observation). The eland population has increased from 19 animals in 1985 to 67 in 1999, growing at an exponential rate of 8,5% and an average finite growth rate of 14,1% (Figure 47). Although the population is still growing exponentially, their impact on key vegetation features in the reserve is becoming visible. At the current growth rate, it is estimated that the eland population should reach a 100 animals by 2002. However, it is recommended that the population be kept at 80 animals.

The waterbuck population in the reserve is increasing at a mean finite growth of 17.4%, and exponentially at 8.67%. The population stabilized at between 30 and 45 animals since 1997, and 15 individuals were introduced, bringing the current population to 60 animals (Figure 48). An important component in the waterbuck habitat is their association with water. This feature, in combination with cover and open grassland are the main characteristics of waterbuck habitat (Estes 1990).

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11 Newbery, RE. Field ecologist, Rustenburg Nature Reserve, Rustenburg

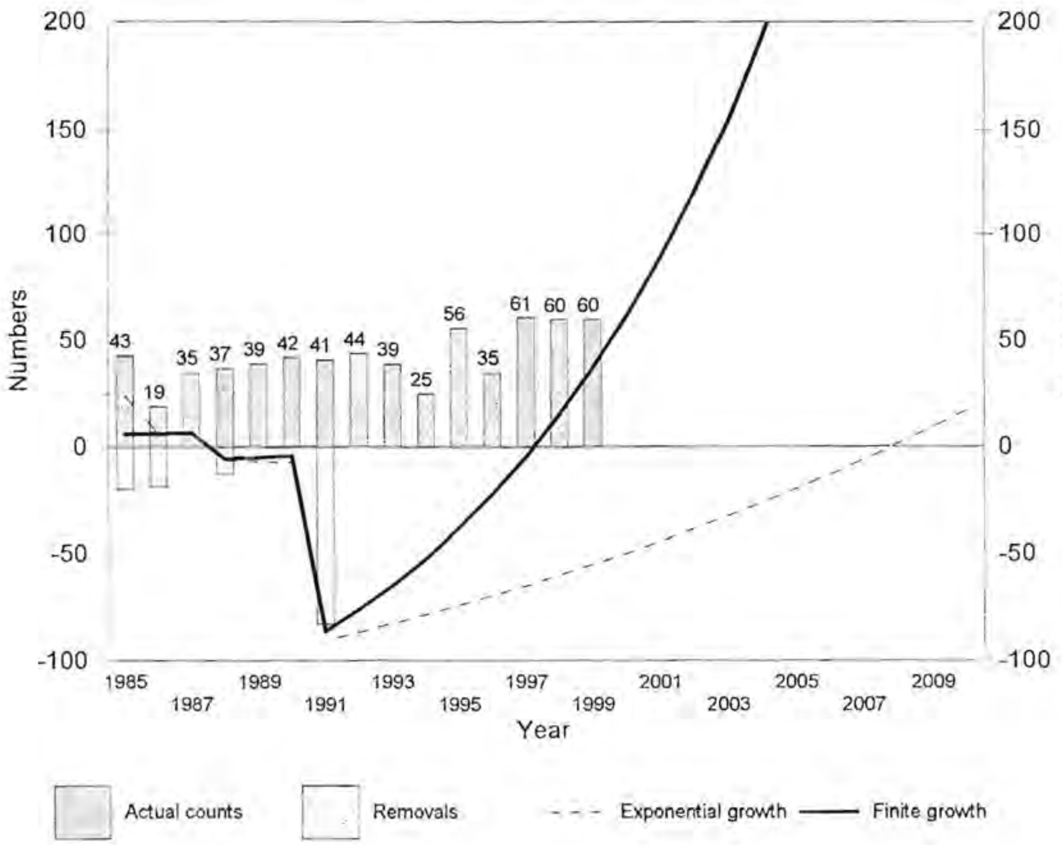

Figure 46: The trend in the population of impala on Rustenburg Nature Reserve since 1985

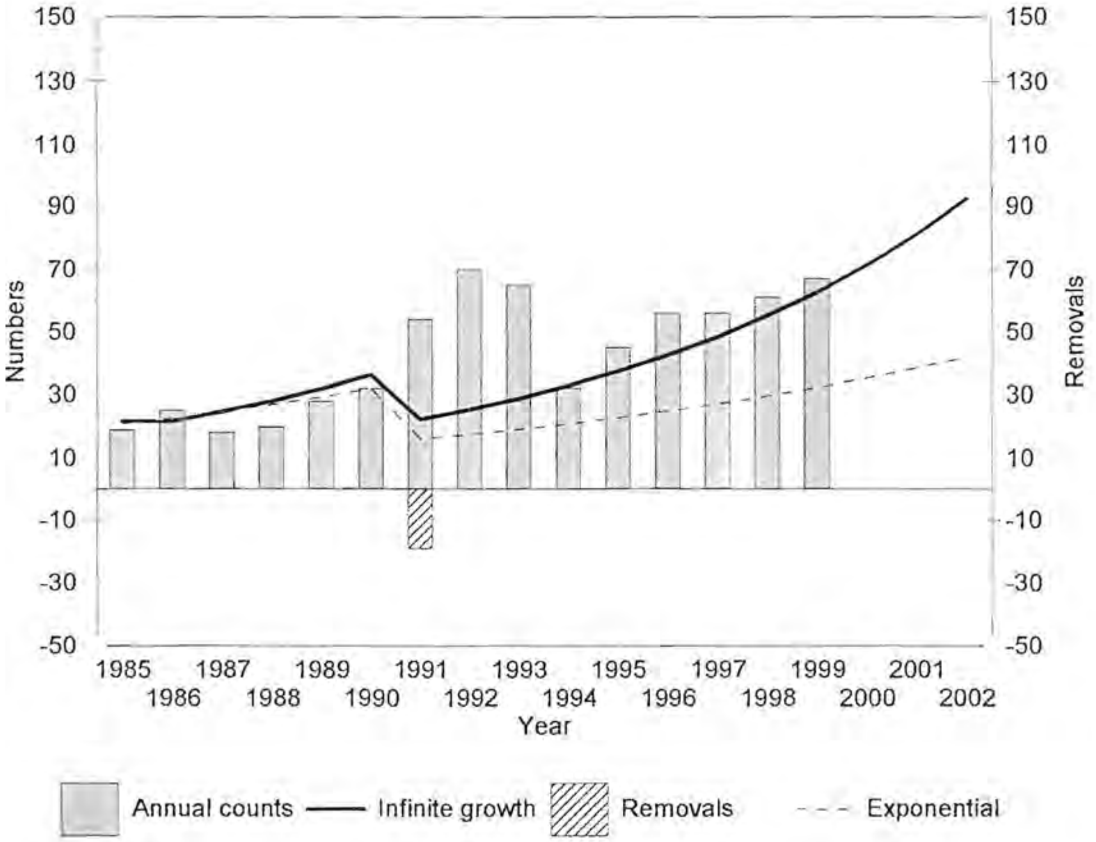

Figure 47: The trend in the population of eland on Rustenburg Nature Reserve since 1985

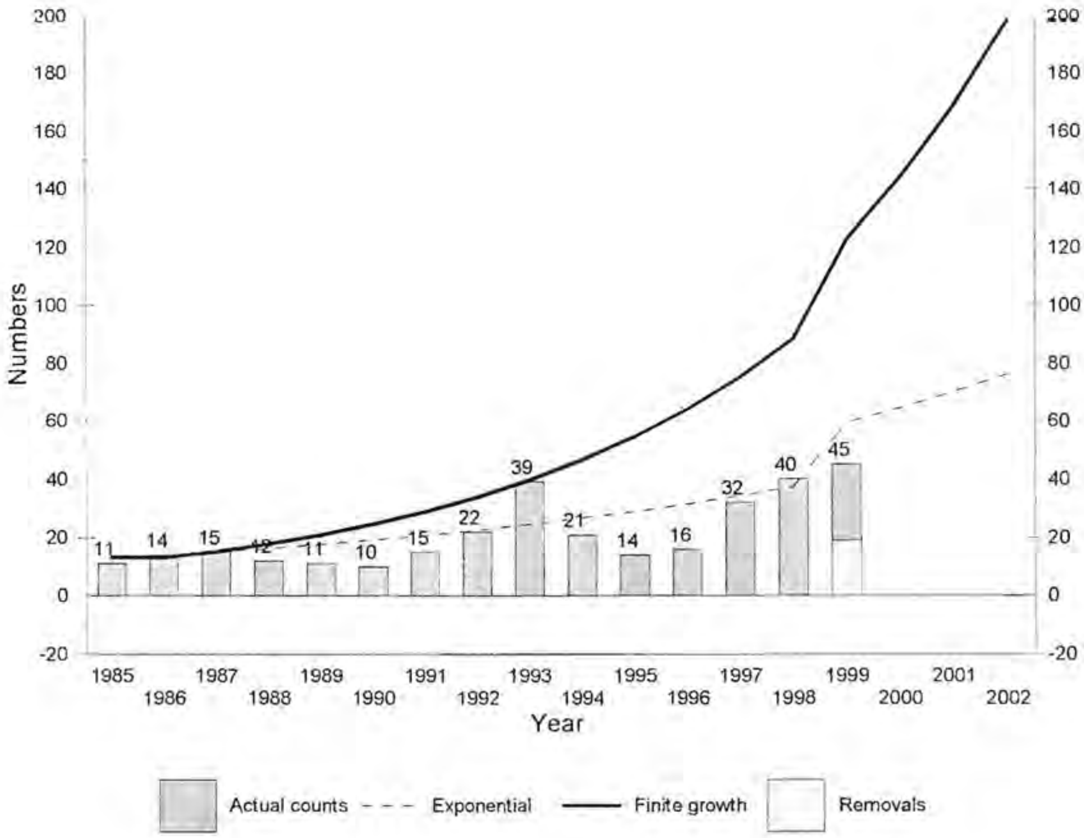

Figure 48: The trend in the population of waterbuck on Rustenburg Nature Reserve since 1985

They also prefer areas with tall grass and accumulated litter (Beardall *et al* 1984). This is contradicted in a study by Wentzel *et al* (1991). His studies indicated a significant difference between the preferred areas of buffalo and waterbuck, with waterbuck preferring areas with low phytomass in varying degrees of over utilization. In the Zambesi valley they also occur on rocky slopes near the river (Skinner *et al* 1990). In Rustenburg Nature Reserve they are associated with areas of long grass in and around the reedmarsh in the central basin, and the bottom lands in the southeasterly valleys. The herbaceous layer in the lowlying areas of these valleys is dominated by *Panicum maximum*, a good quality grass preferred by waterbuck (Skinner *et al* 1990). As waterbuck is in direct competition with sable antelope, their numbers should not be allowed to increase to levels where they will impact on sable.

Zebra uses a wide range of habitats, from open areas with long grass (De Wet 1988; Wentzel *et al* 1991) to open woodland (Estes 1990). Although they are not very selective for specific grass species, they, however, prefer long palatable grasses (De Wet 1988; Dekker *et al* 1996) and will avoid unpalatable woody species (Wentzel *et al* 1991). Zebra is successful and prolific in Rustenburg Nature Reserve, making up the bulk of the animal biomass on the reserve. The population increases at a mean finite growth rate of 12,9%, and an exponential rate of 9.66%(Figure 49). Burchell's zebra are classified as Type I herbivores and they can, together with Type III herbivores cause drastic changes in the habitat, which can be to the detriment of Type II animals, i.e. sable and roan (Collinson & Goodman 1982) and also impact adversely on the primary objective of Rustenburg Nature Reserve. Zebra numbers on the reserve should be allowed to flux between 150 and 200 animals.

Red hartebeest occur in open grasslands and open woodland, avoiding dense woodland (Estes 1990; Skinner *et al* 1990). Kok (1975) have found that hartebeest preferred the transitional zones between open woodland and grassland in the Willem Pretorius Nature Reserve. Bull herds will move into thicker woodland, allowing the females to use the grasslands and fringes of open

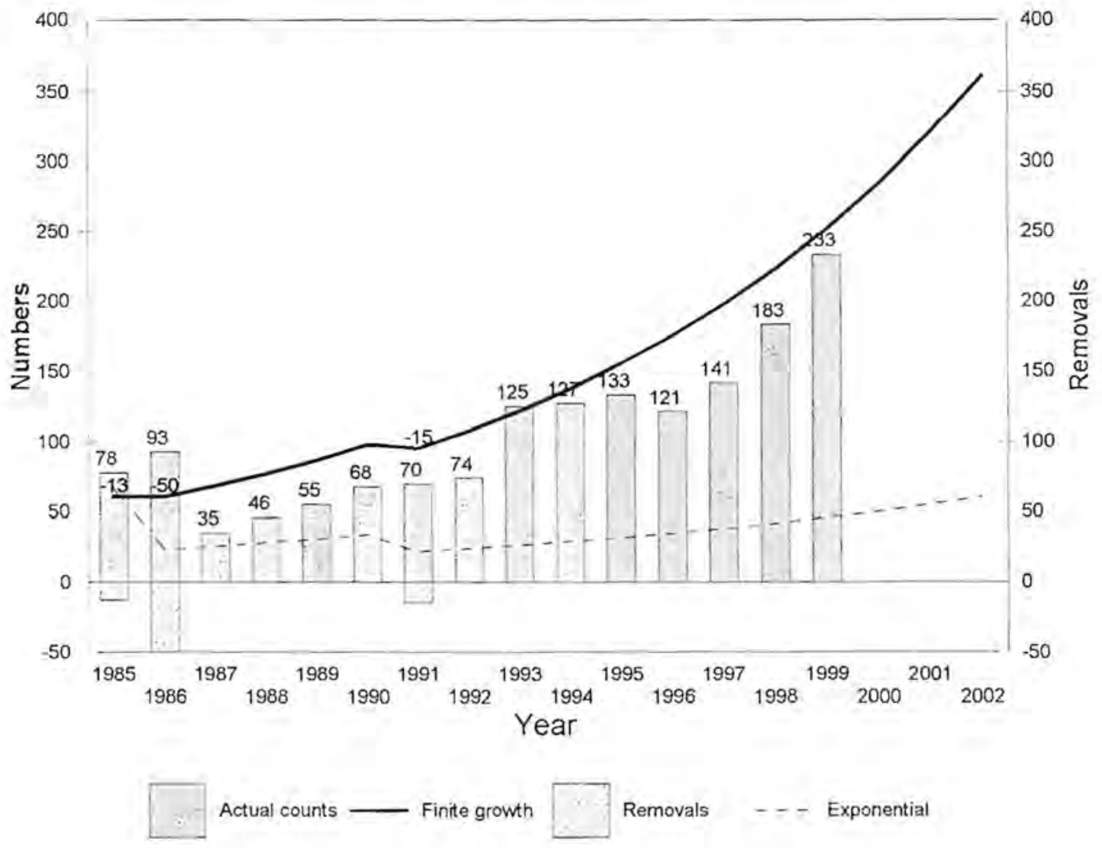

Figure 4?: The trend in the population of zebra on Rustenburg Nature Reserve since 1985

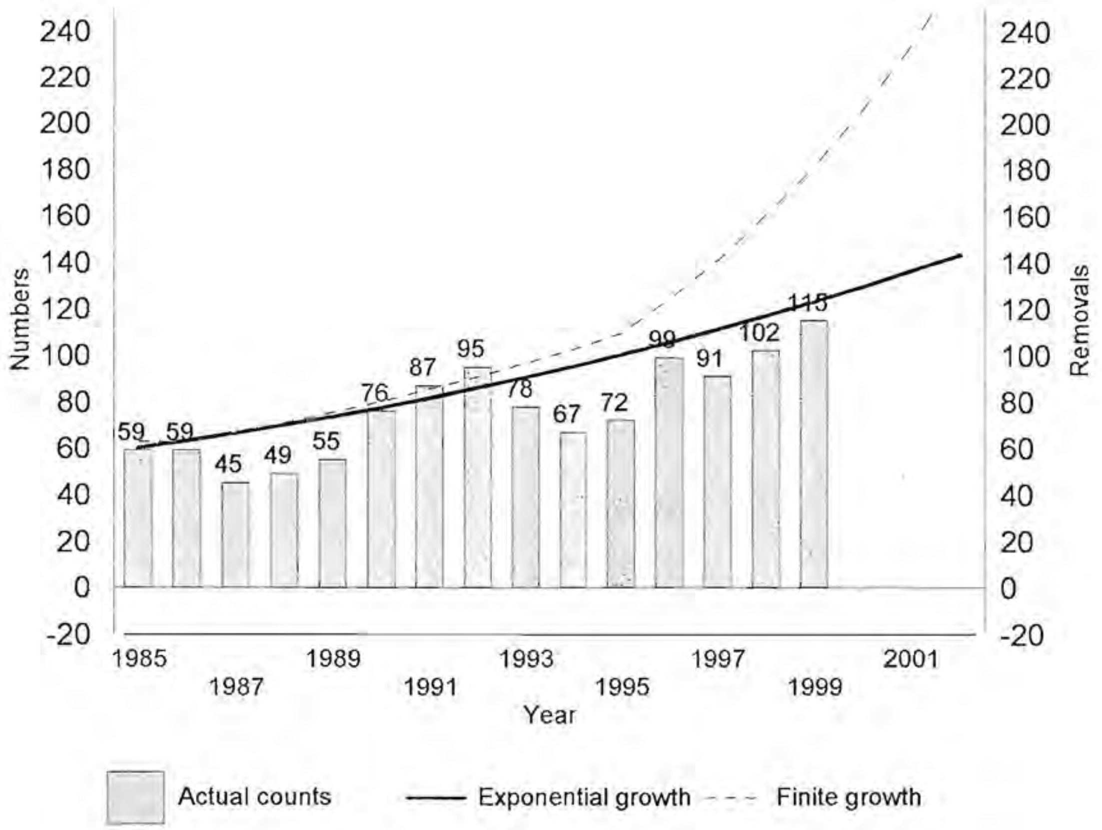

Figure 5 0: The trend in the population of red hartebeest on Rustenburg Nature Reserve since 1985

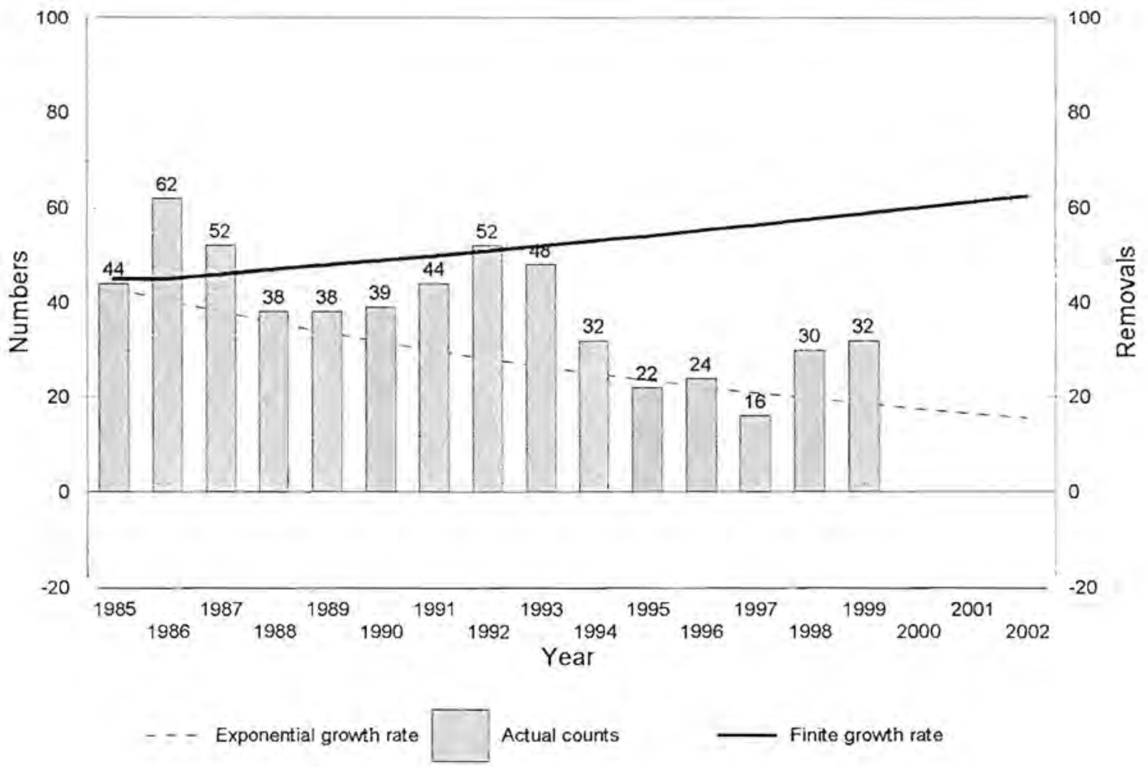

Figure 51 : The trend in the population of springbuck on Rustenburg Nature Reserve since 1985

woodlands (Kok & Opperman 1975). This segregation between the sexes in a specific area is a possible mechanism to reduce intraspecies competition (Kok & Opperman 1975). The trend in the red hartebeest population on the reserve shows distinct inclines and declines, and increasing to levels beyond the previous peak. The population are growing slowly at a mean finite rate of 6.4% and exponentially at a rate of 5.26%(Figure 50). They occur predominantly in the grassland in the central basin and the open *Protea caffra* woodlands on the northern plateau. They do not compete directly with sable, but as a Type III animal (Collinson & Goodman 1982), their numbers should be closely monitored.

Springbuck prefer open plains in the arid parts of the country (Estes 1990). They avoid mountainous areas, rocky hills, thick woodlands and areas of tall grass (Skinner *et al* 1990). They are generalist feeders, preferring more dicotyledons than monocotyledons (Liversidge & Gubb 1994). This makes the reserve a very marginal area for springbuck. This fact is reflected in the performance of springbuck on the reserve. The population grew at a very slow mean finite rate of 2.1%, and shows a negative exponential growth of -5.81%, indicating that the population is heading towards extinction on the reserve (Figure 51). A weak negative correlation (r^2 =0.35) exist between rainfall and springbuck numbers, where springbuck numbers increased during dryer periods and decreased during the wetter years. Managing habitat for springbuck on the reserve will imply a strategy of transforming the status of the veld from climax and sub-climax to veld dominated by pioneer grass species and forbs. This is not compatible with the primary objective of the reserve, *viz.* catchment conservation. Springbuck should therefore be removed from the reserve, or merely be managed as a species to enhance diversity for game viewing. The latter option is recommended.

Kudus prefer the bottom lands and foot slopes of the eastern range of valleys in the reserve. The trend in the kudu population in the reserve is difficult to explain, and it is excepted that the population is a relative open population, moving in and out of the reserve as the environment changes. The precision and accuracy of the kudu counts is not known. However, the same complexities and problems in the use of aerial counts in wooded areas are also applicable to kudu (Collinson 1985).

Kudu is not regarded as an important species to be managed and seems to be regulating their own numbers by moving in and out of the reserve. As residential development moves closer to the reserve's boundaries, this will have to be reviewed.

Giraffe is essentially browsers (Oates 1972), but will also graze grass and shrubs. They have a broad habitat preference ranging from dry savannas scrub to woodland (Goodman & Tomkinson 1987). They avoid forests and open grassland (Skinner *et al* 1990). Males tend to retract into densely wooded habitats which promotes sexual segregation. Another important habitat requirement is a horizontal or gently undulated surface. Giraffe avoids rocky hills and steep slopes (Ebedes[12] *pers.comm*). Gerber (1989) attribute the steep and rocky slopes on the reserve as a limiting factor in niche selection on the reserve. According to Furstenburg (1991) the feeding selection of giraffe is determined by:

- Condensed tannins in browse material
- Palatability and moisture content of the feeding material
- Nutritional value of food
- Availability of feeding plants
- Physical defence agents on the feeding plants and anatomical structure of plant material
- Structure of habitat
- General suitability of the habitat

Gerber (1989) found *Acacia karroo, Acacia caffra* and *Rhus lancea* to be the important feeding plants of giraffe in Rustenburg Nature Reserve. The percentage dry mass condensed tannin concentrations (DCTC) for the three species as determined by Gerber (1989) were 25.03%, 17.16% and 22.78% respectively, relatively high compared to other species favoured by giraffe in the reserve, i.e. *Ziziphus mucronata, Tapinanthus rubromarginatus* and *Diospyros lycioides*. Gerber (1989) also found that giraffe used *R. lancea* significantly more than *Acacia caffra* and *A. karroo*, despite its high DCTC. The reason she gave is that

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R. lancea as an evergreen tree have more leaf material available than the other two species.

Giraffe were introduced into the reserve in the late seventies. Their numbers increased slowly to 14 animals in 1992. Four animals were removed in 1992. In 1993 six giraffe died over a period of two months during June and July. A *post mortem* investigation did not reveal any conclusive reason for these sudden mortalities. Bone pieces found in the rumen suggest osteophagia. This is an indication of mineral deficiencies in their diet. According to Skinner *et al* (1990) giraffe tends to revert to osteophagia in the dry season to gain a balanced ratio of calcium and phosphorous in their diet. According to Ebedes (*pers. comm*) giraffe is very susceptible to infection by *Clostridium botulinum*, causing botulism. This bacteria occurs in carcasses. Further giraffe mortalities resulted in the population currently being a single male. The reserve does not appear to have sufficient habitat for giraffe. Giraffe is a very visual species and important for tourist viewing. The economic implications of re-introducing giraffe into the reserve and managing them intensively needs to be investigated thoroughly.

Roan antelope are very sensitive to changes in their habitat, be it changes in vegetation structure or composition. They select open woodland with tall perennial grasses, often growing in leached, nutrient poor soils (Joubert 1976; Estes 1990; Dörgeloh *et al* 1996), and close to flood plains or steams (Pienaar 1974). In the Weenen Nature reserve, Perrin and Taolo (1999) found that roan antelope are selective feeders, feeding on only two or three grass species in the reserve. They were also observed browsing on dicotyledons in the dry winter months, a possible indication of insufficient grassland habitat (Perrin and Taolo 1999). Palatable perennial species, i.e. *Themeda triandra* were selected throughout the year. Increaser I grass species *Hyparrhenia* species were only selected in the late summer months. As these species became more stemmy, unpalatable and low in nutritional value, they were avoided and Increaser II species, i.e. *Melinus* species and *Eragrostis* species were selected (Perrin and Taolo 1999). A study in Nylsvlei nature reserve indicated that roan selected newly burnt areas (younger than six months) significantly (Dörgeloh 1998). According to Nel (1992) roan antelope calves are very susceptible to infestation by ticks and cytoxcynose and the control of ticks is important in the survival of the calves. Dörgeloh *et al* (1996) also indicated a significant correlation between supplementary feeding and population growth. In two case studies high population growth rates were obtained through intensive management. Animals were fed with a combination of lucerne, antelope cubes and lick, and parasite and predator control were implemented. Competitive species were removed or significantly reduced. Roan were introduced into the reserve in 1999. Only four animals were released. This population needs to be supplemented with at least another 20 animals to make this repatriation viable. The protein and phosphorous deficiencies (Wilson 1975) must be addressed through appropriate licks and supplementary feeding. Both roan antelope and sable antelope are extremely suspicious of any form of supplement block, but will take salt in the field. This offers a way of supplementing minerals as well (Wilson 1975)

Monitoring

To be able to achieve the objective of maximum sustained yields, information on the population dynamics should be collected. Monitoring of these populations will have to be intensified and regular game censuses will have to be done.

Game censusses

To enable the managers to make informed decisions on game management and habitat manipulation, it is necessary to know the number of animals in a protected area and the trends of the different populations (Collinson 1985;Peel 1990; Reilly 1994; Bothma 1995; Reilly & Emslie 1998).

A comprehensive monitoring plan for game needs to provide for the objective of game management in the area. It should also provide management with the correct information, the way in which information on the different species will be collected and the analysis and interpretation of population trends.

Reliable estimates of game numbers depends on accuracy and precision (Peel & Bothma 1995). The results of a census are accurate when it compares favourably with the real situation. Achieving accurate counts are very difficult, as nobody knows exactly how many game are present on the land. The precision is the variation within the counting technique applied, i.e. the difference between successive counts. The smaller the variability, the higher the precision.

Two approaches or strategies can be followed to determined the number of game, depending on the size of the area and distribution of the animals (Collinson 1985; Reilly 1994):

- *Sampling strategy*, where only part of the area is counted. The actual number of animals is determined by extrapolating it to the rest of the area
- *Non sampling strategy* where the total area is counted, assuming that all animals are spotted and counted.

The following criteria are used to select a census technique (Collinson 1985):

- Size of the area
- Game species to be counted
- Funds available
- Manpower available
- Objective of the count

In the development of a census technique for Rustenburg Nature Reserve, three counting techniques were compared with each other. Based on the criteria for selecting a census technique (Collinson 1985), three techniques were selected. These techniques were replicated to determine the variation between them. Unless counts are repeated to estimate variance, a management decision based on unknown variation in the technique can lead to Type I or Type II errors (Reilly & Emslie 1998).

The objective with a game census programme for Rustenburg Nature Reserve is:

- To obtain an accurate estimate of the population numbers and trends:

- Sable	Rare and endangered species, valuable key species, managed for maximum production, needs intensive monitoring, herd composition must be known, sex and age
- Roan	Rare and endangered species, valuble key species, managed for maximum production
- Waterbuck	Key species, competing with sable, roan, need to establish any negative impact on sable and roan species immediately

- To obtain an accurate estimate of the population trends of the following species:

  - Zebra
  - Red hartebeest
  - Eland
  - Kudu
  - Impala

- To obtain an index of the populations of :

  - Oribi
  - Klipspringer
  - Common reedbuck
  - Mountain reedbuck

1. Method

Based on the above-mentioned criteria, a non-sampling census strategy has been adopted on Rustenburg Nature Reserve. The size, variation in habitat types, vegetation characteristics, topography and the distribution of water on the reserve affects the dispersal of animals on the reserve significantly. According to Collinson (1985) these factors will disqualify a sampling strategy completely. Three non-sampling techniques, *viz.* drive census, aerial census and a modified road strip counting technique were evaluated to develop a suitable and reliable census technique.

a. Drive census

Twenty-two observers were used to conduct a drive census. All observers were briefed on the technique the day before the count. A series of slides on the different game species in the reserve was shown to the group. This was to ensure everybody are familiar with the different game species. They were also briefed on the data sheets that would be used, recording of data, radio procedures, consolidation points, each persons' position in the line and reporting lines. A numbering system was used to check for any over-counts or undercounts.

All observers were lined-up on the north-western boundary of the reserve. The line then moved southwards, spreading gradually to cover the "width" of the reserve, with an average maximum distance of 300m between adjacent observers. The northern plateau, the northeastern valley and the central basin were cover between 7:00am to 12:00am, and the southwestern valley were done in the afternoon from 13:00pm to 15:00pm. All game crossing the line of observers was recorded. Radio-communications and strategically positioned lookout posts were used to prevent duplications or undercounts. All recordings were consolidated at the end of the count.

b. Aerial census

A four-seat Bell Jet Ranger III with a pilot, a navigator/recorder seated next to the pilot, and two observers seated in the back were used. The reserve was divided into seven counting blocks, using natural boundaries and similar habitats as basis for delineating boundaries between counting blocks. Each block were systematically search in 400m wide strips at a speed of approximately 60km/h and an altitude of 60 - 100m. The helicopter is easily manoeuvrable to count the herds once they were spotted. All animals were counted, and the counts of bigger herds were confirmed. Information were recorded and consolidated at the end of the count. Counts were done in July after leaf drop. Data were recorded on data sheets.

c. Road strip count

Using the existing road system, a route of 66km in length were laid out throughout the reserve. Care were taken to ensure all habitats in the reserve were covered sufficiently within the constrains of the existing road system. A motorcycle and one observer were used to drive the route through the reserve, visiting high spots and counting all game along the route.

Precision of the counts were reflected as the coefficient of variation, i.e. *x/s* were *x* is the average of the three counts, and *s* is the standard deviation (Reilly & Emslie 1998).

2. Results

The numbers of animals counted during the three techniques represented in Table 11. The aerial census could not be repeated because of cost constrains, and the precision of this technique on Rustenburg Nature Reserve could not be determined. Aerial counts are generally considered to be precise rather than accurate (Peel & Bothma 1995; Bothma *et al* 1990).

Despite the preparations, the drive census yielded poor results for most species, except springbuck (CV = 9.5%). The variation between the counts for the other species were unacceptably high. The poor results can be attributed to the skills level of the staff used during the count, their ability to distinguished between different species, observer fatigue, attitude and visibility between adjacent observers.

Although the road strip count yielded more precise counts for common reedbuck (CV = 0.25%), kudu (CV = 4.7%), sable (CV = 3.5%) and springbuck (CV = 9.5%) numbers were generally much lower than the aerial counts and the drive censusses, except for the sable. This is due to a lot of dead ground that were not covered.

Table 11: Results of aerial counts, drive census and road strip census of game on the Rustenburg Nature Reserve

Species	Aerial						Drive census						Road strip count					
	Replicates			Mean	SD	CV (%)	Replicates			Mean	SD	CV (%)	Replicates			Mean	SD	CV (%)
	1	2	3				1	2	3				1	2	3			
Bushbuck	-	-	-	-	-	-	3	3	0	2	1.414	57.7	-	-	1	1	0	0
Common reedbuck	4	-	-	-	-	-	8	10	6	8	1.633	22.2	1	2	-	1.5	0.5	0.25
Eland	45	-	-	-	-	-	36	28	58	40.67	12.68	48.5	23	4	45	24	16.75	280.7
Giraffe	3	-	-	-	-	-	3	2	3	2.667	0.471	23.1	2	2	2	2	0	0
Impala	23	-	-	-	-	-	8	10	56	24.67	22.17	301.7	14	23	15	17.33	4.028	16.2
Kudu	20	-	-	-	-	-	12	26	12	16.67	6.6	42.5	5	4	9	6	2.16	4.7
Mount. reedbuck	49	-	-	-	-	-	141	108	150	133	18.06	17.8	21	33	18	24	6.481	42
Oribi	2	-	-	-	-	-	6	8	5	6.333	1.247	21.8	-	2	2	2	0	0
Red hartbeest	72	-	-	-	-	-	78	56	108	80.67	21.31	39	76	59	63	66	7.257	52.7
Sable	36	-	-	-	-	-	30	50	47	42.33	8.807	27	38	38	34	36.67	1.886	3.5
Springbuck	22	-	-	-	-	-	31	33	27	30.33	2.494	9.5	24	17	18	19.67	3.091	9.5
Waterbuck	12	-	-	-	-	-	15	26	47	29.33	13.27	79.3	15	5	11	10.33	4.11	16.8
Zebra	133	-	-	-	-	-	127	118	169	138	22.23	22.2	87	43	76	68.67	18.7	349.6

A helicopter count on a farm in the Northern Province yielded a figure that were closest to the control (Peel & Bothma 1995). This count was done on a farm with similar topography and vegetation than Rustenburg Nature Reserve. The road strip and drive census techniques used did not yield significant results at Rustenburg Nature Reserve, except for springbuck , sable and common reedbuck. It is recommended that the helicopter count be use to census game on Rustenburg Nature Reserve, and it be supplemented with ground data collected with the road strip counts.

3. Frequency of counts

The following criteria to establish frequency of counts, were developed at a game census workshop held in Pilanesberg National Park, North West Province[13]

- Where animals are harvested intensively, counts must be conducted frequently to pick up numbers after each removal
- By only conducting counts every second year, harvesting models can be complicated and confused
- At high stocking rates and use, annual counts are important
- At low numbers and low utilization levels, counts can be conducted every second year
- Important and valuable species must be monitored as frequent as possible (Sable, roan antelope, waterbuck)

13 Game census workshop, North West Parks & Tourism Board, held in Pilanesberg on the 12th May 1998

The recommended census strategies for game on Rustenburg Nature Reserve are:

Species	Census strategy
Sable, roan & waterbuck	Aerial census every second year, supplement data with ground observations annually, collect population dynamics data, i.e. sex and age
Zebra, impala, red hartebeest, eland,	Use aerial census every second year, model population numbers for in between years using growth rate of populations
Oribi, klipspringer, common reedbuck, mountain reedbuck	Use an index method to determine population trends

VELD BURNING AS A MANAGEMENT PRACTICE

Fire is an important determinant in the structure and functioning of African savannas(Scholes & Walker 1993). The impact of fire on these systems, depends on, among others, the seasonality, fire frequency and intensity (Shackleton & Scholes 2000).

Fire is an efficient means to manage predefined states of natural vegetation. Fire can be used to:

- remove surplus vegetation and improve access by game,
- to remove moribund and/or unacceptable grass material and improve the nutritional value of the vegetation for grazing and browsing species,
- maintain or achieve plant composition as desired by management objectives,
- reduce fuel load and thus the intensity of fires,
- aid in the control of live stock parasites,
- to recycle nutrients (Scholes & Walker 1993),
- stimulate out-of-season flush,

– and to manipulate animal movement on a farm to promote the homogenous utilization of the veld (Trollope 1989).

Frequency of fire has a marked effect on the woody structure. Studies in the Kruger National Park, South Africa indicated that the density, height, biomass, basal area and stem circumference decreases when fire frequency is increased (Shackleton & Scholes 2000). However, Enslin *et al* (2000) stated that a longer fire return-period does not necessarily enhance tree height. A longer fire return period leads to increased built-up of fuel, resulting in high intensity fires and more top kill, and potentially affecting structure. Mid-summer burns, and fire exclosure resulted in a reduction of woody plants less than 1.75m in height (Enslin *et al* 2000). Research in the Eastern Cape has shown however that burns applied during early summer, when the grass was actively growing, had a negative effect on the productivity, basal cover and botanical composition of the grass sward (Trollope 1989).

Trollope (1984) has stated that the interaction between burning and grazing after fire probably has a greater effect on vegetation than any other aspect of burning, and emphasised that serious damage can be caused by heavy grazing when applied too soon after a burn.

The effect of burning on vegetation depends to a large extent on the type and intensity of a fire (Trollope 1978). Fires can be classified into three broad types of fires:

A *ground fire* that burns below the surface of the ground

A *surface fire* that burns in the herbaceous layer, also referred to as a cool fire

A *crown fire* that burns in the canopies, also referred to as a hot fire.

Depending on the objective of the burn, each type of fire can artificially be created by manipulating the intensity of the fire. The intensity of a fire depends on the amount of fuel available, air temperature, relative humidity and the presence of wind. A ground fire is of no real importance to a wildlife manager, although ground fires have been recorded in Rustenburg Nature Reserve (Momberg, pers.comm[14]). Ground fires are not dealt with any further.

The intensity of fires can be manipulated through applying fires at specific atmospheric conditions and fuel loads. When burning to remove moribund material a cool fire is required to remove the material while doing the least damage to the vegetation. Such a fire will be obtained when air temperature is < 20° C and relative humidity >50%. The minimum fuel load required to carry a fire is at least 1500 kg/ha. These conditions generally prevail during the morning until 11h00 and in the afternoon after 15h30 (Trollope 1989).

When burning to eradicate and/or prevent the encroachment of undesirable plants, a hot fire is required. For this type of fire the air temperature should be >25 to 30°C and the relative humidity < 30%. These conditions generally prevail between 11 h00 and 15 h 30 (Trollope 1989). To obtain an intense fire that will destroy the aerial growth of bush, a grass fuel load of >3500 kg/ha is required.

– Fire regime in Rustenburg Nature Reserve over the past 27 years

Fire has been used as a management tool in Rustenburg Nature Reserve for the past 30 years. A block burning system was designed by Krynauw[15] in 1975 in which the reserve were divided into 5 burning blocks. Each block were visited and subjectively evaluated using the following criteria:

- Grass species composition and whether it was stable, dominated by perennial grass species.
- Visual assessment of fuel
- Signs of moribund material
- Time since previous burn

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14 M. Momberg, previous ranger Rustenburg Nature Reserve, now Resource Utilization officer, Pilanesberg National Park, North West Province

15 D.J. Krynauw, Previous Ecologist, currently lecturer at Faculty Agricultural Sciences, Dept. Nature Conservation, Pretoria Technikon, Pretora

Fire was mostly applied at the end of the growing season, after the first summer rains and immediately before spring growth. Under these conditions, the recovery of the vegetation is fast (Bosch *et al* 1984).

In 1994, early winter burns were implemented in Rustenburg Nature Reserve. The first fires of the burning season were ignited in April. Mid-winter and late-winter fires were ignited depending on the size of the area already burnt during that year.

– Methods

Since 1972 each fire, controlled, lighting or accidental, in Rustenburg Nature Reserve were mapped on a 1:10 000 topographical map. A 25ha grid map was overlain onto a 1:10 000 map of the reserve (Brockett *et al* in press). Each cell was evaluated and an estimate of the percentage of the cell that burnt was entered into a spreadsheet, where each cell represented a 25ha square. The burnt area for each year was then calculated. The burn/unburnt of each cell were calculated over the period 1972-1999 and the average fire intervals for each cell were determined.

– Results

The fire regime of an ecosystem has four components (Scholes & Walker 1993):

- Frequency, reciprocal of the time between fires
- Intensity, rate of energy release
- Season of burning
- Type of fire

Until the mid-nineties, most fires in the reserve were applied in the early spring, after the first rains. This philosophy of early spring burns was applied in most other savanna-areas. It was argued that this will cause most damage to trees, and least damage to herbaceous (Scholes & Walker 1993). The impact of this philosophy on the vegetation structure and composition is not clear, but from research done in Kruger National Park (Shackleton & Scholes 2000, Enslin *et al*

2000) on the impacts of season of burning on the woody component, it can be deducted that it should have had an effect on the woody structure in the reserve.

The results of the analysis are depicted in figures 52 and 53. Figure 52 represents the percentage of the reserve burnt each year. The results indicated that an average of 13.71% of the reserve burnt each year. However, the area burnt each year increased slowly from 7.9% in the seventies to 19.6% in the nineties. In 1989, 45.01% of the reserve was burnt. From 1981 to 1986 a very conservative burning policy was applied, and less than 2% of the reserve was burnt each year, except for 1983 when 2.11% was burnt. This was followed by a period between 1987 to 1991 when more than 20% of the reserve were burnt each year for five consecutive years. The conservative approach and small areas burnt resulted in increased fuel loads and very high intensity fires were recorded (Drotski, pers comm[16], Krige, pers. comm[17]). This was due to a less conservative fire management policy been adopted and followed on the reserve since the mid-eighties.

The fire interval, that is period between successive fires, for the reserve is 8.21 years. Certain cells have not been burnt for the past 18 years (Fig 53). These cells are located on swallow bedrock, where fuel loads have not sufficient to carry the fire.

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16 Andre Drotski, previous warden Rustenburg Nature Reserve, now stationed at Roodeplaatdam Nature Reserve, Gauteng Nature Conservation

17 Frans Krige, previous warden, Rustenburg Nature Reserve, now stationed at Dullstroom, Mpumalanga Parks Board

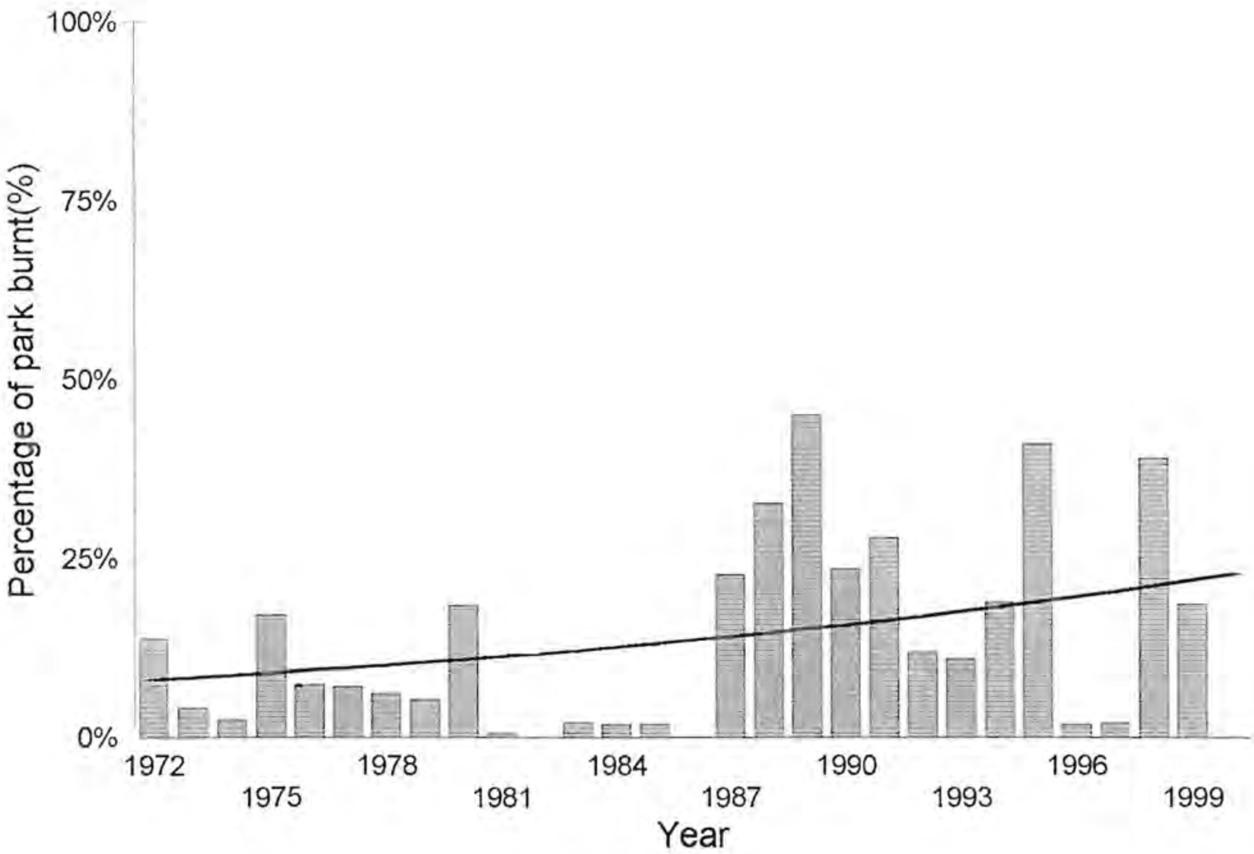

Figure 52: The size of the area of the Rustenburg Nature Reserve reserve that burnt each year since 1985

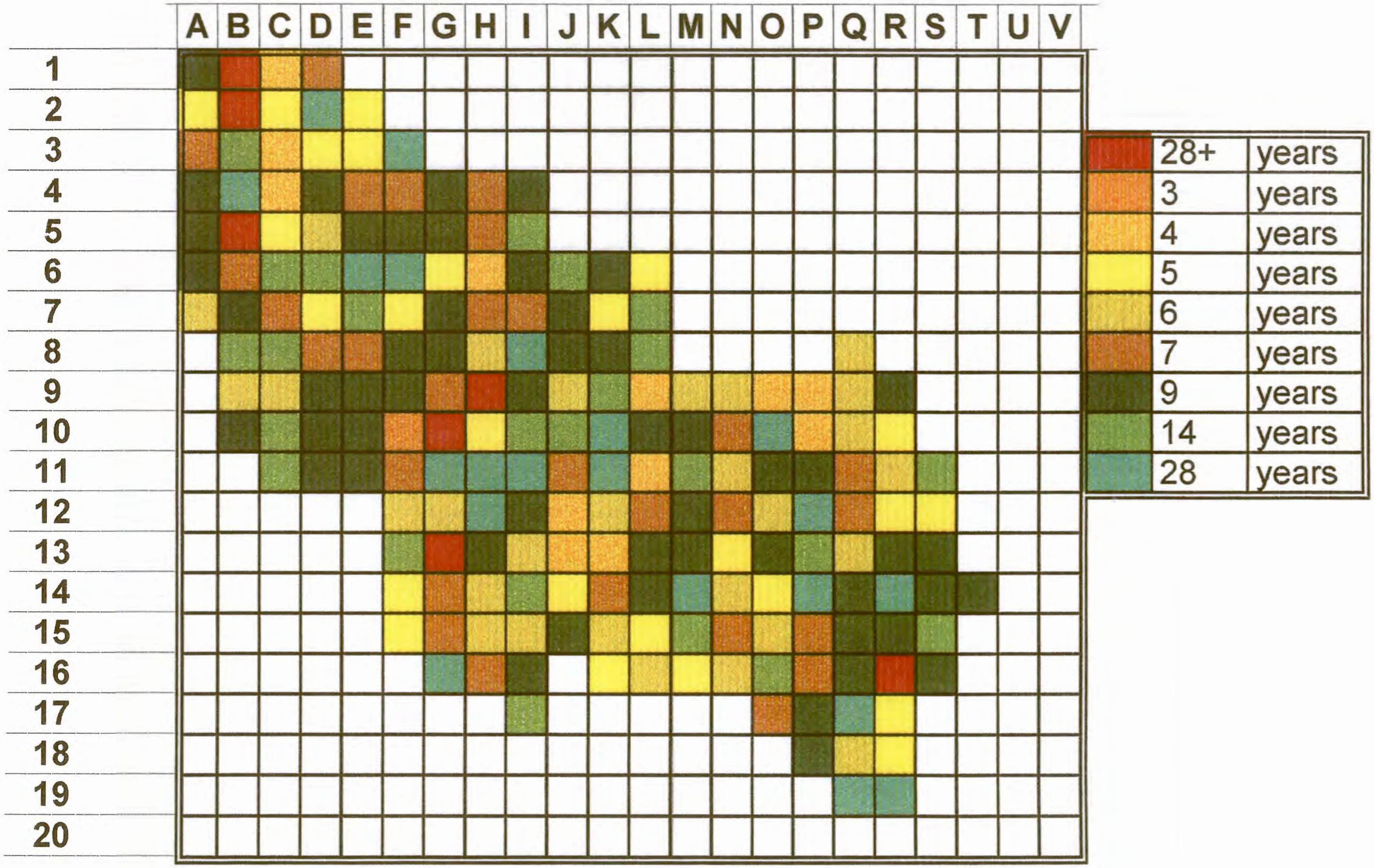

Figure 53: The fire interval in a 25 ha cell in the Rustenburg Nature Reserve reserve since 1985

– Discussion

Fire is an important ecosystem driver (Scholes & Walker 1993). The interaction between a multi-species herbivore complex and the effects of a "natural" fire regime have been important on the evolution of African savannas (Scholes & Walker 1993). No conclusive evidence exists that burning *per se* increases water yields (Bosch *et al* 1984). However, uncontrolled burning may lead to a deterioration of the factors that ensure good infiltration, water yield regulation, low sediment and high biomass production (Edwards 1984).

The fire regime for Rustenburg Nature Reserve must primarily aim to sustain stream flow and to optimize water quality. In order to achieve this dense vegetation cover should be maintained during the rainy season (Edwards 1984) to maximize infiltration and peculation rates. Secondary, fire will also be used at as tool to improve the grazing value of the vegetation for game species such as sable and roan. An appropriate fire regime aimed at achieving the vegetation and faunal objectives on the reserve will only be developed and refined through the process of adaptive management. Environmental factors such as rainfall, prolonged drought, herbivory and accidental or unplanned fires are variables impacting on vegetation structure and composition, thus preventing a rigid or prescribed burning program.

Protea caffra trees in the *Aloe greatheadii- Themeda triandra* Tall Open Woodland on the northern plateau of the reserve suffered damage during a hot fire in 1994. The extreme intensity of the fire was due to large fuel loads, combined with high day temperatures (<25 °C) and low humidity(late winter)(Drotski, pers. comm)[18]. The *Burkea africana-Themeda triandra* Tall Open Woodland has been identified as an important feature to be conserved in the reserve. Research in the Kruger National Park indicated that high fuel loads associated with dry atmospheric

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18 Andre Drotski, previous warden Rustenburg Nature Reserve, now stationed at Roodeplaatdam Nature Reserve, Gauteng Nature Conservation, Gauteng Province

conditions leads to increased top kill among larger trees(Shackleton & Scoles 2000). It is therefore recommended that these conditions be avoided in order to maintain the current structure, and to allow for the recruitment of young *Burkea africana* seedlings. . To achieve this, high fuel loads in this community need to be avoided, as well as fires at the end of the winter season.

To ensure sufficient vegetation cover to maximize water infiltration, no fires should be introduced during the rainy season. In situations of severe run-off, the absence of cover can lead to accelerated erosion and sedimentation, which will affect the quality of water and the infiltration rate.

CHAPTER 7
CONCLUSIONS

The management of Rustenburg Nature Reserve as a mountain catchment area implies optimal use of natural resources to ensure continuous delivery of a sustained flow of good quality water. The effect of management practises and development inside the reserve on these objectives must be measurable.

The aims of the study are summarized as follows:

- To develop a monitoring system to detect changes in the ecosystem that can affect the sustained flow of water from this mountain catchment.
- To achieve this, the scale at which monitoring should take place, needed to be established.
- It also required a complete description of the physical and biological environment and the delineation of functional units for management
- The basis for monitoring is the evaluation and interpretation of change along degradation gradients which needed to be developed for each management unit.
- The development of guidelines for the monitoring of other components at appropriate scale and level.

The description of the physical environment entailed a literature study of the geology and geomorphology of the area and subsequent development of the geology map. The geological map and topographic characteristics of the reserve were used to develop a soil map for the reserve. The soil map gives an overview of the broad soil differences on the reserve.

To delineate management units at an appropriate and practical scale, that will respond uniformly to management practises, the vegetation of the reserve was described and relative homogenous management units were delineated.

The floristic variation within the management units in Rustenburg Nature Reserve is influenced by topography and substrate. Phytosociological differences between vegetation communities and management units were distinguished on the basis on aspect, moisture content, soil depth and clay content. A distinct difference between communities associated with the drier environments on the plateau, hill slopes and the open areas of the central basin and the communities associated with the wet habitats along the vlei and water streams were detected. Variations in soil depth resulted in differentiation between vegetation communities. Communities associated with open bedrock and shallow soils occurring on the plateau and upper hill slopes were distinguished from communities occurring on the meduim-deep to deep Hutton soils in the central basin and small secluded pockets in the valleys. A weak gradient in clay content was detected. Clayish soils and associated communities, mainly confined to the alluvial soils in the valleys were distinguished from the communities associated with sandy soils.

These units form the basis for management and monitoring of the vegetation component of the reserve. Four units were described:

I. *Selaginella dregei - Oldenlandia herbacea* Open Shrubland
II. *Becium obovatum - Elionurus muticus* Tall Grassland
III. *Ziziphus mucronata - Rhus leptodictya* Closed Woodland
IV. *Pteridium aquilinum - Miscanthus junceus* Moist Grassland

The *Selaginella dregei - Oldenlandia herbacea* Open Shrubland management unit occurs on shallow soils and exposed quartzite sheets on the high lying areas of the reserve.

The *Becium obovatum* - *Elionurus muticus* Tall Grassland management unit is associated with the medium deep to deep soils on the foot slopes and in the central basin area of the reserve, the valley between the summit and the eastern range of quartzite ridges.

The *Ziziphus mucronata* - *Rhus leptodictya* Closed Woodland consists of the woodland and forest communities in the reserve. This management unit is found on the low-lying slopes and low-lying areas of the eastern valleys in the study area. The tree and shrub layer are very prominent.

The *Pteridium aquilinum* - *Miscanthus junceus* Moist Grassland management unit represents the moist habitats on the reserve. The soils in this management unit vary from deep, black clay soils underlying the reed swamp to deep apedal soils adjacent to the streams in the southern section of the central basin. This management unit occurs on a high water table and certain communities in this management unit are submerged. Species diversity in this management unit is low and confined to species associated with moist conditions.

The dynamics of the vegetation in the first three management units and the response thereof to disturbances were described along a vegetation gradient. Vegetation gradients were developed for each of the units using multivariate techniques. The response of herbaceous species to different levels of grazing impacts was modelled to identify key species to be used in the interpretation of the degradation gradients in each vegetation unit. Regression analysis was used to establish the reaction of the individual species. Responsive species were divided into Decreasers, Increaser 1, Increaser 2, Increaser 3 and Increaser 4 categories. Evident from analysis were that species responded differently to grazing impacts under different physical and environmental conditions, and certain species were classified into more than one category. Species also displayed an inconsistent response to utilization between different management units. A set of key species were distinguished for each management unit.

No significant erosion levels of were recorded in the *Selaginella dregei* -

Oldenlandia herbacea Open Shrubland management unit, due to the large areas of open bedrock and shallow soils underlying this management unit. *Coleocloa setifera* colonizes and stabilizes bare areas of bedrock in this management unit effectively.

In the *Becium obovatum - Elionurus muticus* Tall Grassland management unit no significant relationship between the level of utilization and the number of plant species recorded were detected, but species seems to disappear when the veld is not utilized. In this unit, erosion appears in the seriously over-utilized sector of the degradation gradient, jeopardising the objective of slow release of high quality effluent.

The *Ziziphus mucronata - Rhus leptodictya* Closed Woodland management unit shown a significant difference between the number of species in the less utilized sectors of the degradation gradient and the species numbers recorded for the severely over-utilized sectors. Maximum species diversity is obtained when the veld is lightly utilized, but species seems to disappear when the veld is severely over-utilized. No significant erosion was found in the under-utilized and lightly utilized sectors of the gradient. Moderate levels of erosion were detected in the seriously over-utilized sector of the degradation gradient of this management unit, thus indicating that this level of utilization in this management unit will result in undesired veld condition in terms of management objectives for the reserve.

Fixed monitoring sites were positioned in each management unit. The residual value of all five sites in Management Unit 1 is less than the Maximum Acceptable Residual value, which is half of the Euclidean length of the first axis. These are therefore representative of the vegetation in the management unit. In Management unit 2, the residual value of four sites is less that the acceptable value. The residual value of the fifth site is unacceptably high and can therefore not be considered for this gradient. The residual value of three sites in management unit 3 is more than the maximum acceptable value and cannot be fitted into the constructed models. Seven sites of the ten sites elected are within the acceptable maximum value. A three-year survey interval is recommended, as it reduces noise and allows a particular management action to take effect.

Rustenburg Nature Reserve's secondary management objectives, to maintain the scenic beauty and integrity of this area in the Magaliesberg, to conserve biological diversity and natural processes and to preserve the cultural and archaeological heritage, and to allow public access to the reserve, have to be achieved within the limits imposed by its primary objective, *viz.* sustained yield of quality water. It is recommended that the management of the vegetation on Rustenburg be aimed at maintaining a high canopy and basal cover. This will ensure the desired soil structure, which will improve the water retention capabilities of the soil. Also, alien vegetation with high water requirements must be removed.

The stocking rate of game should vary in accordance to the management objectives of the reserve. On Rustenburg Nature Reserve the objective with game management to use game as a management tool to manipulate vegetation structure and composition, to use a sustainable basis, to improve the visitor's experience to the reserve and, where feasible, to breed endangered and valuable species, i.e. sable antelope and roan antelope.

The principle of adaptive management will be applied to refine the stocking rate of the game on the reserve. Game census strategies were also recommended for the various game species in accordance with the census objectives.

The fire regime in Rustenburg Nature Reserve over the past 27 years was analysed. An average of 13.71% of the reserve burnt each year. The fire interval for the reserve is 8.21 years, although certain cells located on swallow bedrock have not been burnt for the past 18 years.

Ecological management objectives and monitoring procedures for Rustenburg Nature Reserve, North West Province

by

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SUMMARY

The objectives of the Rustenburg Nature Reserve were analyzed and the optimal use of natural resources to ensure continuous delivery of a sustained flow of good quality water was set as the primary ecological management objective for the reserve. This aims at maintaining the vegetation composition and structure on the reserve to maximize water retention. The effect of management practices and development inside the reserve on these objectives must be evaluated and must be measurable.

An analysis of the geology, soils, climate and hydrology of the Rustenburg Nature Reserve were used to classify and described the vegetation on the reserve. Fifty-one vegetation communities, sub-communities and variations were identified. The association of these communities towards each other was modeled through ordination and four relative homogenous management units were delineated.

I. *Selaginella dregei - Oldenlandia herbacea* Open Shrubland
II. *Becium obovatum - Elionurus muticus* Tall Grassland
III. *Ziziphus mucronata - Rhus leptodictya* Closed Woodland
IV. *Pteridium aquilinum - Miscanthus junceus* Moist Grassland

These units form the basis for management and monitoring of the vegetation component of the reserve.

Multivariate processing techniques were used to develop degradation gradients for management unit 1,2 & 3. Management unit four represents the moist habitats on the reserve, and includes the reed marsh and riverine vegetation along the Waterkloof spruit. These gradients were developed to gain an understanding of the dynamics of the vegetation in the different management units, and the responses thereof to disturbances. These gradients will provide the basis for evaluating and interpreting change along degradation gradients in each management unit. The response of herbaceous species to different levels of grazing impacts was modeled to identify key species to be used in the interpretation of the degradation gradients in each vegetation unit. Regression analysis was used to establish the reaction of the individual species. Responsive species were divided into Decreasers, Increaser 1, Increaser 2, Increaser 3 and Increaser 4 categories.

A monitoring system aimed at detecting changes in the ecosystem that can affect the sustained flow of water from this mountain catchment was developed. Fixed monitoring sites were positioned in each management unit. The residual value of monitoring sites in all management units was less than the Maximum Acceptable Residual value, which is half of the Euclidean length of the first axis. A three-year survey interval is recommended, as it reduces noise and allows a particular management action to take effect.

The stocking rate of game should vary according to the management objectives of the reserve. On Rustenburg Nature Reserve the objective with game management to use game as a management tool to manipulate vegetation structure and composition, to be used on a sustainable basis to supplement income, to improve the visitor's experience to the reserve and, where feasible, to breed endangered and valuable species, i.e., sable and roan antelopé. The principle of adaptive management will be applied to refine the stocking rate of the game on the reserve. Game census strategies were also recommended for the various game species in accordance with the census objectives.

Ekologiese bestuursdoelwitte en moniterings prosedures vir Rustenburg Natuurreservaat, Noordwes Provinsie

deur

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Magister Scientiae (Natuurbestuur)

OPSOMMING

Die doelwitte van die Rustenburg Natuurreservaat is ontleed en die optimale gebruik van die reservaat se natuurlike hulpbronne om 'n volgehoue lewering van hoë kwaliteit afloop te verseker is as die primêre ekologiese bestuursdoelwit geidentifiseer. Dit impliseer die bestuur van die plantegroei samestelling en struktuur om water retensie te maksimaliseer. Die effek van bestuurspraktyke en ontwikkeling binne die reservaat

op hierdie doelwitte, moet voortdurend evalueer word en moet derhalwe meetbaar wees.

'n Ontleding van die geologie, grond, klimaat en hidrologie van die Rustenburg Natuurreservaat is gebruik om die plantegroei op die reservaat te klassifiseer en te beskryf. Een-en-vyftig plantegroei gemeenskappe, sub-gemeenskappe en variasies is geidentifiseer. Die verhouding tussen die gemeenskappe is deur ordinering gemoduleer en vier bestuurseenhede is onderskei:

I. *Selaginella dregei - Oldenlandia herbacea* Oop Struikveld
II. *Becium obovatum - Elionurus muticus* Lang Grasveld
III. *Ziziphus mucronata - Rhus leptodictya* Geslote Boomveld
IV. *Pteridium aquilinum - Miscanthus junceus* Nat Grasveld

Hierdie eenhede vorm die basis vir die bestuur en monitering van die plantegroei komponent op die reservaat.

Meerveranderlike ontledingstegnieke is gebruik om degradasie gradiente vir bestuursgebiede 1, 2 & 3 te ontwikkel. Bestuurseenheid 4 verteenwoordig die klammer habitats op die reservaat, insluitende die rietbeddings en oewerplantegroei langs die Waterkloof spruit. Hierdie gradiente is ontwikkel om die dinamika van die plantegroei in die verskillende bestuursgebiede te verklaar, asook die reaksie daarvan op versteuring. Hierdie gradiente voorsien 'n basis om veranderinge wat langs die gradient plaasvind mee te evalueer en te verklaar. Die reaksie van die kruidlaag op verskillende vlakke van benutting is ook gemodelleer, en is gebruik om sleutel kruidspesies te identifiseer om te gebruik in die interpretering van die degradasie gradient in elke plantegroei eenheid. Regressie analises is gebruik om die reaksie van individuele spesies te ondersoek. Spesies wat betekenisvolle reaksies getoon het, is in Afnemers, Toenemers 1, Toenemer 2, Toenemer 3 en Toenemer 4 kategorieë ingedeel.

'n Moniterings stelsel wat die veranderinge in die ekosisteem wat die volgehoue vloei van afloop vanuit die opvanggebied kan opspoor, is ook ontwikkel. Vaste moniteringspunte is in elke bestuursgebied uitgeplaas. Die residuele waarde van die punte wat uitgeplaas, is minder as die Maksimum Residuele Waarde wat toegelaat kan word, dit is die helfde van die Euklidiese afstand van die eerste as. 'n Opname elke drie jaar word aanbeveel, aangesien dit korttermyn variasies wat met kort opeenvolgende opnames gepaard gaan, sal elimineer.

Die wildlading op 'n reservaat moet varieer na gelang van die bestuursdoelwitte van die reservaat. Op Rustenburg Natuurreservaat word wild gebruik as 'n meganisme om plantegroei samestelling en struktuur mee te manipuleer, dit word op 'n volhoubare wyse benut om inkomste aan te vul deur lewende verkope, om besoekers se ondervinding tydens 'n besoek te verbeter en skaars en waardevolle diere soos swartwitpens en bastergemsbok sal ook hier geteel word. Die beginsel van aanpassingsbestuur sal gebruik word om die wildlading te verfyn. Wildsensus strategieë in lyn met die sensus doelwitte vir die onderskeie spesies word ook voorgestel.