CHAPTER 11

WILDLIFE MANAGEMENT RECOMMENDATIONS

INTRODUCTION

Giles (1969) defines wildlife management as the science and art of changing the characteristics and interactions of habitats, wild animal populations, and men in order to achieve specific human goals by means of the wildlife resources. These goals are often for recreational activities such as hunting, game-viewing, hiking or for ecological and economic reasons. Wildlife management should begin when a natural area is enclosed by a fence (Bothma 1995b). Once such artificial situations have been created it becomes necessary to manage the impact of the continuous presence of animals on the veld. When the natural migration routes of the animals are cut off it is necessary to supply the animals with adequate sources of water and food.

According to Bell (1983) the following aspects contribute to the wildlife management plan of any game reserve:

- The collection and supply of comprehensive data on the specific ecosystems.
- Practical limitations regarding finances, manpower and expertise.
- Patterns of land-use in neighbouring areas.
- Definition of limitations within which permissible changes in the biological and environmental components may take place.
- Estimates of future trends and needs, both of the area and its users.
- The compilation of a time plan for the management plan.
- Description of each realistic option that may exist in order to attain the management objectives.
- Choice of preferred options and description of the management plan based thereupon.
- Constant re-evaluation of the management plan and goals.

The information gathered during the resource inventory allow the following recommendations to be made:

- Veld management.
- Fire management.

- Grazing management.
- The harvesting of selected natural resources.
- Animal management
- Monitoring programme
- Research recommendations

These aspects are dealt with briefly below:

ADAPTIVE MANAGEMENT

Clear-cut plans for the ecological management of game ranches are lacking (Grossman, Holden and .F.H. Collinson 1999). Many components and variables make up the management of multi-species systems and a flexible management approach is therefore required. The concept of adaptive management is extremely important in the management of natural areas. Adaptive management is the term used for the system of making management decisions based on the lessons learnt from one's mistakes (Stuart-Hill 1989a). It entails the *a priori* construction of a set of management-related hypotheses, the implementation of the relevant management actions, the monitoring of the outcome of such actions, and the evaluation of the results obtained against the expectations (Grossman *et al.* 1999). Should the results agree with the predictions, the knowledge base is deemed reliable and management procedures may be continued. When not, further research and hypothesis generation or a change in management action is required. The system is practised by monitoring the following key parameters: rainfall, temperature, stocking rate, animal performance, vegetation and habitat use, veld condition, fires, bush encroachment, predator-prey relationships, alien plants, diseases, soil erosion and the effects of tourism (Stuart-Hill 1989a; Trollope 1990). By keeping reliable and complete records of these parameters the manager will be able to identify certain trends and adapt or maintain his or her management techniques as dictated by such trends.

VELD MANAGEMENT

Veld management on a game ranch is determined by the objectives for the ranch (Grossman *et al.* 1999). The type of veld management practices followed are determined by the objectives of the game ranching enterprise and it is therefore important that a clear statement of objectives be made. The following recommendations are made in light of the objectives of the management of Sango Ranch:

FIRE MANAGEMENT

Fire is regarded as a natural factor in the environment of southern Africa (Tainton 1999a) and plays an important ecological role in plant communities (Tainton and Mentis 1984). The grassland and savanna areas of southern Africa are prone to fire and support many plant and animal species that have evolved adaptations in response to fire (Mentis and Bigalke 1979, *In:* Tainton 1999a). In southern African ecosystems fire has several important advantages (Van Heerden 1992; Tainton 1999a; Van Rooyen pers. comm.). The moribund, unproductive material is removed allowing new palatable growth to become established; the height of browse material can be lowered, fire can be used to promote rotational grazing, and bush encroachment and parasites can be controlled. The objectives of using fire in wildlife management programmes must be taken into account when considering veld burning. The most common objectives of veld burning in southern African ecosystems are (Tainton 1999a; Van Rooyen pers. comm.):

- To burn the unpalatable growth from the previous seasons which, when not removed would smother the new season's growth.
- To control the encroachment of undesirable plants.
- To lower the height of browse.
- To promote rotational grazing.
- To contribute to fire control by reducing fuel loads.
- To maintain or develop grass cover for soil and water conservation.

For the ecological management of Sango Ranch all of these objectives must be taken into account. In Chapter 7 it was shown that some areas of Sango Ranch have large amounts of moribund grass material which pose a fire hazard. Fire would then be used in these areas to remove this moribund grass and promote the growth of green grass. Van Wilgen and Willis (1988) report that accurate predictions of veld fires depend on correct information on the available combustible material. It is therefore imperative that fuel loads be monitored to enable predictions on fire behaviour. The disc pasture meter as applied in Chapter 7 can be used for such purposes. Readings must be taken at the end of the growing season just before burning is considered. To ensure accurate fuel load estimates it is important that the disc pasture meter be calibrated for the specific conditions on Sango Ranch. The following recommendations of Trollope (1990) can be used in the decision-making model (Van Heerden 1992) to decide whether veld burning is required in a certain area on Sango Ranch:

1. Does bush encroachment pose a problem?

   Yes..............2

   No................5

2. Is the grass fuel load >4 000 kg per ha

   Yes...............3

   No................4

3. Burn the veld under the following conditions:

   Air temperature >25 ºC

   Relative humidity of the air < 30%

4. Wait until >4 000 kg per ha of grass material has accumulated before burning.
5. Is moribund grass material present and is it smothering fresh green growth?

   Yes..............6

   No...............9

6. Is the grass fuel load between 2 000 and 4 000 kg per ha?

   Yes..............7

   No...............8

7. Burn the veld under the following conditions:

   Air temperature < 20ºC

   Relative humidity of the air> 50%

8. Wait until grass material has accumulated to at least 2 000 kg per ha.
9. Burning is not necessary.

In sweetveld areas the herbaceous layer is mostly maintained by climate , and fire is less important there (Hatch 1999). In sweetveld areas fire is only used as a management tool to control bush encroachment, to remove moribund grass material and to promote rotational grazing. On Sango Ranch moribund material is currently only found in the *Combretum apiculatum* Woodland Management Unit. The other areas are well utilised and fuel loads from August to September are too low to require burning. Monitoring of fuel loads and the decision-making model above will determine when each management unit requires burning. An important point is that the veld must only be burned under specific fuel loads and atmospheric conditions depending on whether bush encroachment is to be controlled or whether moribund grass material is to be removed. Hot fires are required for bush encroachment control while cool fires are required to remove moribund material. Hot fires kill off young woody plants but are detrimental to the herbaceous layer (Trollope 1990). However, hot fires in certain cases will not kill larger trees. It is then necessary to apply mechanical or chemical control. Fire can be used to lower the height of browsing material (Van Rooyen pers. comm.). Atmospheric conditions in all cases must be stable because unstable conditions can result in fires running out of control. Because grazing ungulates concentrate on freshly burned areas it is important that a large enough area be burned to prevent trampling and overgrazing (Trollope 1999). The type of fire must also be considered. Backfires significantly depress grass regrowth compared to head fires (Trollope 1978). On the other hand, head fires cause a greater topkill of the stems and branches of trees and shrubs than do backfires because of the fire's greater intensity and because more of the heat is carried up into the tree and shrub canopies (Trollope and Tainton 1986).

The season of burning is important because out of season burning can reduce grass vigour, reduce the basal and canopy cover of grass, increase the runoff of rainwater and causes increased soil erosion (Van Rooyen *et al.* 1996). The best time to burn to remove moribund material is in the late winter and early spring and immediately after the first rains when the plants are dormant (August to September) (Everson 1999). Late winter and early spring burning has a disastrous effect on the already actively growing grass plants (Everson 1999). To control bush encroachment, burning of the grass in late winter (August to September) before the spring rains is recommended (Brown 1997). The dry and dormant grass causes a high intensity fire (Van Oudtshoorn 1992). Burning to achieve an out of season green flush is not advised and should be avoided at all costs (Van Rooyen *et al.* 1996). Frequent veld burning can result in either increased or decreased tree density (Trollope 1999). When burning to remove moribund material, the required frequency of burning will depend on the rate at which grass material accumulates (Trollope 1989). As a guide, such accumulation should not exceed 4 000 kg per ha. Burning frequency will then depend on rainfall and grazing intensity (Trollope 1999). Grass fuel loads of >4 000 kg per ha pose a fire hazard and such areas must be burnt with great caution and under cool moist conditions, when the objective is to remove moribund grass material.

The practice of block burning that is currently practised in some wildlife areas may be problematic on Sango Ranch because refinements are often required to accommodate erratic and unpredictable rainfall and unplanned fires (Grossman *et al.* 1999). Homogeneous fire regimes could also reduce spatial heterogeneity and ecosystem resilience (Scholes and Walker 1993). It is therefore important to vary the fire parameters such as frequency, seasonality, intensity and type of fire spatially and temporally across the landscape (Van Wilgen and Scholes 1997). Patch-burning may provide a mosaic of newly burned, recently burned and unburned areas on large game ranches (Grossman *et al.* 1999). Grossman *et al.* (1999) made the following recommendations: fires should be point-ignited under diverse weather and fuel conditions and should be allowed to follow their own course. This will depend on the fuel load and veld condition, wind direction, existence of barriers such as rivers, rocky, bare or sparsely-grassed areas and roads, rather than the conventional firebreaks used in block burning. Naturally ignited fires should also be allowed to follow their own course. Following such a veld burning approach poses severe dangers. The danger of out of control fires is present and this must be taken into consideration. It is therefore important to be able to apply the approach of Grossman *et al.* (1999) in a safe manner. The decision-making model given above should be used when deciding on when and where to burn. The relationship between rainfall and grass fuel load will ensure that the frequency of veld burning will be varied. In this way no burning will take place in low rainfall periods and vice versa. The time of burning can also be varied but burning must always occur when the grass plants are dormant. It is recommended that firebreaks be established aside from rivers, bare areas and roads to enable the containment of fires when required. A further safety factor is the necessity for sufficient manpower and water to control fires during controlled burns.

Different vegetation types react differently to burning (Tainton 1999a). In general, grassland and savanna areas are well adapted to fire. Fire is also important in wetlands (Tainton 1999a). Forest areas are sensitive to fire and when exposed to frequent hot fires are reduced to grasslands (Tainton 1999b). It is recommended that only cool fires be applied in the *Diospyros mespiliformes* Management Unit of Sango Ranch.

GRAZING AND BROWSING MANAGEMENT

The common approach to grazing management in South Africa has been one of facilitating periods of rest during which the grass plant is not defoliated (Grossman *et al.* 1999). The rotational grazing system has been used to achieve this rest period. However, this system is difficult to practice in a free-ranging game situation such as is found on Sango Ranch. Controlled burning, licks and the opening and closing of water points have all been used to facilitate a form of rotational grazing on game ranches (Van Oudtshoorn 1992). It is, however, difficult to enforce rotational grazing on a game ranch, because animals show specific habitat preferences. For example, impala and blue wildebeest are attracted to the nutrient-rich areas while sable antelope and roan antelope prefer nutrient-poor areas to minimise competition (Grossman *et al.* 1999). It would then be difficult to attract impala and blue wildebeest out of the well-utilised areas into the nutrient-poor areas of a ranch. This situation exists on Sango Ranch. High density animals such as the blue wildebeest, impala and warthog are attracted to the nutrient-rich habitats of the *Acacia tortilis* Open Woodland, *A. tortilis* Closed Woodland and *Diospyros mespiliformes* Riverine Management Units while the *Colophospermum mopane* Woodland and *Combretum apiculatum* Woodland Management Units contain the low density species such as sable antelope. The veld condition scores shown in Chapter 6 reflect this situation. The *Acacia tortilis* Open Woodland Management Unit is currently being overutilised by impala and blue wildebeest. In cases of sweetveld overutilisation it is recommended that the stocking rates of the high density animals be reduced. In the sourish areas stocking with long to medium grass grazers such as white rhinoceros, hippopotamus, buffalo, zebra, roan antelope, sable antelope and waterbuck is recommmended (Grossman *et al.* 1999). The preferred habitats of the high-density species will be underutilised and at lower stocking rates these species can be attracted from overutilised areas to underutilised areas. The high-density species mentioned above are all water-dependent and are never found more than 5 to 6 km away from permanent water (Grossman *et al.* 1999). To ensure that certain sweetveld areas remain under-utilised, waterholes in these areas can be closed. During the wet season this is impossible because natural pans are filled by rainfall. It is therefore recommended that long to medium grass grazers such as white rhinoceros, hippopotamus, buffalo, roan antelope, sable antelope and waterbuck be introduced to the *Combretum apiculatum* Management Unit which is currently only utilised lightly. Water points should be established in the *Combretum apiculatum* Woodland Management Unit to supply water to the water-dependent species. The placement of water points in this management unit must be done with great care to avoid veld degradation and erosion. The stocking rate of the high-density selective grazers such as impala and blue wildebeest within the *Acacia tortilis* Open Woodland Management Unit should be reduced in order to allow the veld condition to improve.

Browsing management is difficult to apply because browsers are mostly water-independent. Where browse overutilisation is evident, the stocking rate of browsers should be reduced. The ratio of grazers to browsers is also important and is discussed under stocking rate. See Table 53 for the recommended stocking rates for impala and blue wildebeest

STOCKING RATE

The stocking rate of different animal species is dependent on the condition and type of the different available habitats and on the objectives of the area (Bothma, Van Rooyen and Du Toit 1995). The stocking rate of the different herbivores will primarily be a function of the grazing and browsing capacity of the area (Trollope 1990). The grazing and browsing capacity of the study area is discussed in Chapter 9. The main aim of the study area is to manage for optimal game-viewing, maximum species diversity and trophy quality. Trollope (1990) suggests that for these purposes the stocking rate should be close to the ecological carrying capacity of the study area. However, Bothma (1995a) recommends that animals be stocked at the same rate as during drought conditions. The current consensus is that a conservative stocking rate should be adopted on game ranches (Grossman *et al.* 1999).

The feeding behaviour of different animal species must be considered when making stocking rate recommendations (Orban 1995). Mentis (1981) classified ruminant and non-ruminant ungulates according to their feeding behaviour into bulk grazers, concentrate grazers and browsers. As most of the tree species in the area are deciduous and many animals graze and browse, Mentis and Duke (1976) suggested a ratio of approximately 2 bulk grazers to 2 concentrate grazers to 1 browser. In sweetveld areas Trollope (1990) recommends a ratio of 2 bulk grazers to 1 selective grazer. This then allows for the grass being eaten by browsers to be included in the calculation of stocking rate (Danckwerts 1989). Also, the bulk grazers feed mostly on tall, coarse grass and this then opens up the veld for the concentrate grazers that prefer short grass (Odum 1983). The sex ratio of the animals should also be correct so as to ensure a healthy reproductive population (Bothma *et al.* 1995). The grazing and browsing capacity should also be assigned in the ratio 2 bulk grazers: 1 selective grazer: 1 browser (Owen-Smith 1999).

Aerial count estimates of the animals (Joubert 1998, 1999b) on Sango Ranch and the total number of browsers and grazers for 1999 are presented in Table 52. The aerial counts were conducted during 1999 and 2000 by the staff of Sango Ranch and the Save Valley Conservancy. Aerial counts substantially underestimate the true population and the degree of undercounting also varies between animals and regions (Bothma 1995d). The aerial count estimates for Sango Ranch are probably an underestimate, especially for animals such as the kudu, bushbuck, nyala and bushpig. No buffalo appear on the list in Table 52 because these animals moved onto Bedford Block to the south of Sango Ranch (Figure 2) during the dry period when the aerial count was conducted (Goosen pers. comm.)[3]. The ecological capacity for Sango Ranch for average rainfall periods was estimated at 7 056 large stock units while that for below average rainfall years was estimated at 3 737.2 large stock units (Chapter 9). The current number of large stock units present on Sango Ranch is 46.1 % of the estimated ecological capacity. However, the current number of browsing LSU's exceeds the browsing capacity for average rainfall years by 66 % and the below average rainfall browsing capacity by 73 % (Table 52). A browse line can already be seen in the *Colophospermum mopane* Woodland Management Unit and this is probably due to the high number of browsers.

The ratio of bulk grazers: selective grazers:mixed feeders:browsers is currently approximately 19:8:39:34 (Table 52). The recommended ratio is 25:35:20:20 (Van Rooyen pers. comm.).[11] This indicates that, proportionately, too many browsing animals and too few bulk and selective grazers are present on Sango Ranch. The recommended animal numbers for average rainfall years for Sango Ranch is given in Table 53. The animals are stocked at 59.4 % of the total capacity. As

Table 52. The current number of browsing and grazing game on Sango Ranch, Save Valley Conservancy, Zimbabwe.

FEEDING CATEGORY*	ANIMAL	NO. OF ANIMALS.***	LSU CONVERSION*	% GRASS IN DIET**	% BROWSE IN DIET **	LSU EQUIVALENT*	GRAZING LSU'S	BROWSING LSU'S
Non-selective grazers	Hippo	16	0.45	100	0	35.8	35.8	0.0
	White rhino	1	0.36	80	20	2.8	2.2	0.6
	Zebra	587	1.51	100	0	388.7	388.7	0.0
Sub-total		604	-	-	-	427.3	426.7	0.6
Selective grazers	Sable	24	1.70	100	0	14.1	14.1	0.0
	Wildebeest	321	2.00	100	0	160.5	160.5	0.0
	Waterbuck	2	2.00	100	0	1.0	1.0	0.0
Sub-total		347	-	-	-	175.6	175.6	0.0
Mixed feeders	Eland	417	0.92	30	70	453.3	125.1	317.3
	Impala	1088	5.20	50	50	209.2	104.6	104.6
	Nyala	1	4.40	20	80	0.2	0.0	0.2
	Warthog	114	4.04	100	0	28.2	28.2	0.0
Sub-total		1620	-	-	-	690.9	257.9	422.1
Browsers	Black rhino	4	0.64	0	100	6.3	0.0	6.3
	Bushbuck	1	7.62	0	100	0.1	0.0	0.1
	Elephant	90	0.25	30	70	360.0	108.0	252.0
	Giraffe	114	0.63	0	100	181.0	0.0	181.0
	Kudu	395	1.84	0	100	214.7	0.0	214.7
Sub-total		514	-	-	-	762.1	108.0	654.1
Total		3085	-	-	-	2055.9	968.2	1076.8

* Van Rooyen, Bredenkamp and Theron (1995), **Snyman (1989), *** Joubert (1998, 1999b)

Table 53. Recommended numbers for browsing and grazing game during average rainfall years on Sango Ranch, Save Valley Conservancy, Zimbabwe.

FEEDING CATEGORY*	ANIMAL	LSU CONVERSION*	LSU EQUIVALENT*	NO. OF ANIMALS.	% GRASS IN DIET**	% BROWSE IN DIET **	NO. GRAZING LSU'S	NO. BROWSING LSU'S
Non-selective grazers	Buffalo	0.93	374.5	350	100	0	374.5	0.0
	Bushpig	4.50	66.0	300	100	0	66.0	0.0
	Hippo	0.45	87.4	39	100	0	87.4	0.0
	White rhino	0.36	22.0	8	80	20	17.6	4.4
	Zebra	1.51	990.0	1500	100	0	990.0	0.0
Sub-total		-	1539.9	2197	-	-	1535.5	4.4
Selective grazers	Tsessebe	2.60	88.9	234	100	0	88.9	0.0
	Reedbuck	7.62	9.5	50	40	60	3.8	5.7
	Roan	1.55	25.6	40	90	10	23.0	2.6
	Sable	1.70	154.0	275	100	0	154.0	0.0
	Wildebeest	2.00	1000.0	2000	100	0	1000.0	0.0
	Waterbuck	2.00	383.0	766	100	0	383.0	0.0
Sub-total		-	1661.2	3365	-	-	1652.7	8.3
Mixed feeders	Eland	0.92	216.0	200	30	70	64.8	151.2
	Impala	5.20	190.0	1000	50	50	95.0	95.0
	Nyala	4.40	9.2	40	20	80	1.8	7.4
	Warthog	4.04	150.0	600	100	0	150.0	0.0
Sub-total		-	565.2	1840	-	-	311.6	253.6
Browsers	Black rhino	0.64	14.9	9	0	100	0.0	14.9
	Bushbuck	7.62	19.5	150	0	100	0.0	19.5
	Elephant	0.25	159.6	40	30	70	47.9	111.7
	Duiker, common	10.74	3.0	100	0	100	0	3.0
	Giraffe	0.63	63.2	40	0	100	0.0	63.2
	Klipspringer	14.27	14.0	200	10	90	2.1	14.0
	Kudu	1.84	135.0	250	0	100	0.0	135.0
	Sharpe's Grysbok	20.54	7.5	150	20	80	1.5	6.0
	Steenbok	16.18	9.0	150	10	90	0.9	8.1
Sub-total		-	425.7	989	-	-	52.4	375.4
Total		-	4192.0	8391	-	-	3552.2	643.7

Van Rooyen *et al.* (1995)

** Snyman (1989)

Table 54. Recommended numbers for browsing and grazing game during below average rainfall years on Sango Ranch, Save Valley Conservancy, Zimbabwe (* Van Rooyen *et al.* (1995) ** Snyman (1989)).

FEEDING CATEGORY*	ANIMALS	LSU CONVERSION*	LSU EQUIVALENT*	NO. OF ANIMALS.	% GRASS IN DIET**	% BROWSE IN DIET **	NO. GRAZING LSU'S	NO. BROWSING LSU'S
Non-selective grazers	Buffalo	0.93	171.2	160	100	0	171.2	0.0
	Bushpig	4.50	26.4	120	100	0	26.4	0.0
	Hippo	0.45	42.6	19	100	0	42.6	0.0
	White rhino	0.36	22.0	8	80	20	17.6	4.4
	Zebra	1.51	462.0	700	100	0	462.0	0.0
Sub-total		-	724.2	1007	-	-	677.2	4.4
Selective grazers	Tsessebe	2.60	38.0	100	100	0	38.0	0.0
	Reedbuck	7.62	4.8	25	40	60	1.9	2.9
	Roan	1.55	25.6	40	90	10	23.0	2.6
	Sable	1.70	67.2	120	100	0	67.2	0.0
	Wildebeest	2.00	500.0	1000	100	0	500.0	0.0
	Waterbuck	2.00	175.0	350	100	0	175.0	0.0
Sub-total		-	810.6	1635	-	-	805.1	5.5
Mixed feeders	Eland	0.92	108.0	100	30	70	32.4	75.6
	Impala	5.20	95.0	500	50	50	47.5	47.5
	Nyala	4.40	9.2	40	20	80	1.8	7.4
	Warthog	4.04	50.0	200	100	0	50.0	0.0
Sub-total		-	262.2	840	-	-	131.7	130.5
Browsers	Black rhino	0.64	14.9	9	0	100	0.0	14.9
	Bushbuck	7.62	9.1	70	0	100	0.0	9.1
	Duiker, common	10.74	1.5	50	0	100	0	0
	Elephant	0.25	119.7	30	30	70	35.9	83.8
	Giraffe	0.63	31.6	20	0	100	0.0	31.6
	Klipspringer	7.0	14.0	100	10	90	0.7	6.3
	Kudu	1.84	64.8	150	0	100	0.0	64.8
	Sharpe's Grysbok	20.54	4.0	80	20	80	0.8	3.2
	Steenbok	16.18	4.8	80	10	90	0.5	4.3
Sub-total		-	262.9	539	-	-	37.9	219.5
Total		-	2061.4	4071	-	-	1651.9	359.9

mentioned previously, the sweetveld areas of the ranch are being overutilised while the sourveld areas are being utilised lightly. Buffalo will utilise the *Combretum apiculatum* Woodland Management Unit and it is recommended that buffalo be reintroduced in this management unit. The number of selective grazers, especially sable antelope and roan antelope should be increased in this management unit. The recommended stocking rate for below average rainfall periods for Sango Ranch is presented in Table 54.

The recommended number of LSU's is 55 % of the ecological capacity for below average rainfall periods. It is recommended that the stocking rates be adapted according to the rainfall cycle being entered into. Rainfall cycles on Sango Ranch are discussed in Chapter 2.

The recommended sex ratios are presented in Table 55. These sex ratios are based on Bredenkamp (pers comm)[13]. The recommendations on the stocking rate of herbivores are a broad guideline and a first approximation. Veld condition, animal condition, grazing and browsing capacity and herbaceous biomass should all be monitored annually to allow for an adaptation of the stocking rates as required. The adaptive management approach as given in Figure 92 should be followed. When determining stocking rates, the current number of animals per management unit should be determined in order to derive the stocking rate per management unit. As already mentioned, overutilisation of the sweetveld areas will take place when the stocking rate is based on the area as a whole and not on the individual management units.

PLACING AND CONTROL OF WATER POINTS

Water points are often areas of severe herbivore utilisation intensity (Thrash 1993) where overgrazing may occur during the dry season (Thrash, Nel, Theron and Bothma 1991a). Thrash *et al.* (1991a, 1991b) concluded that the provision of a permanent but artificial supply of drinking water for animals in the Kruger National Park has had a negative impact on both the woody and herbaceous vegetation in the vicinity of the dams. The herbaceous vegetation also seemed more sensitive to disturbance by animals. Ayeni (1975) found that vegetation degradation at small waterholes in the Tsavo National Park was only slight, while at large

Table 55. The recommended sex ratio and herd size for animals on Sango Ranch, Save Valley Conservancy, Zimbabwe (Bredenkamp pers. comm.)[13].

ANIMAL	*SEX RATIO**	*MINIMUM HERD SIZE*
Black rhinoceros	2:3	5
Buffalo	1:3	5
Bushbuck	1:3	8
Bushpig	2:3	5
Duiker	1:1	4
Eland	1:3	12
Elephant	0	10
Giraffe	3:5	8
Grysbok, Sharpe's	1:1	4
Hippopotamus	2:3	5
Impala	1:4	25
Klipspringer	1:1	4
Kudu	1:3	12
Nyala	3:7	10
Reedbuck, common	3:7	10
Roan antelope	3:5	8
Sable antelope	3:5	8
Steenbok	1:1	6
Tsessebe	3:5	8
Warthog	2:3	10
Waterbuck	3:5	8
White rhino	1:2	6
Wildebeest, blue	1:4	15
Zebra, Burchell's	3:7	10

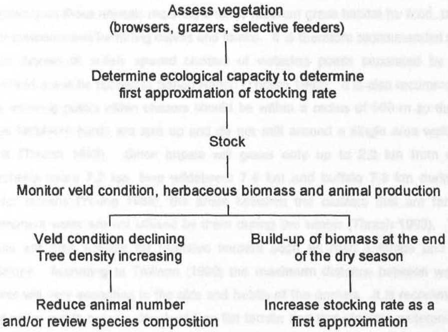

Figure 92. Flow chart showing the adaptive management approach that can be applied in grazing and browsing management and stocking rate determination on game ranches in southern African savannas (Grossman *et al.* 1999).

permanent waterholes a fair amount of vegetation destruction was observed during the dry season. Factors to be considered when developing water points are the topography, type of soil, type of veld, distance from other watering points and the movements of animals (Du Toit 1995). Numerous and closely distributed water points result in an overlap in areas of high use and will result in a decline in habitat diversity (Grossman *et al.* 1999). A series of overlapping zones of high use, where thicket and a herbaceous layer dominated by annuals predominate, will impact negatively on those animals requiring a tall to medium grass habitat for food, shelter from predators and for hiding calves and lambs. It is therefore recommended that a water system of widely spaced clusters of watering points separated by large waterless areas be applied in Sango Ranch (Thrash 1993). It is also recommended that watering points within clusters should be within a radius of 500 m so that the large herbivore herds are split up and do not mill around a single area waiting to drink (Thrash 1993). Since impala will graze only up to 2.2 km from water, Burchell's zebra 7.2 km, blue wildebeest 7.4 km and buffalo 7.8 km during the winter months (Young 1989), the areas between the clusters that are far from permanent water are not utilised by them during the winter (Thrash 1993). These areas are then suitable for selective feeders such as roan antelope and sable antelope. According to Trollope (1990) the maximum distance between watering points will vary according to the size and habits of the anmals. It is recommended that water points only be developed on flat terrain and that closable waterpoints be used because of the ease of manipulation for the purposes of rotational resting (Trollope 1990). Trollope (1990) also suggests that very few water points should be placed in sensitive sweetveld due to its susceptibility to overgrazing. The system of adaptive management (Stuart-Hill 1989a; Grossman *et al.* 1999) should be applied to determine the effects of the animals on the vegetation at the water points and further management actions can then be applied as the situation requires.

THE HARVESTING OF SELECTED PLANT SPECIES

Several indigenous southern African plants are harvested and used for personal and commercial purposes (for example Palgrave 1956; Watt and Breyer-Brandwijk 1962; Goldsmith and Carter 1981; Cunningham 1987; Cunningham 1988, 1990a, 1990b; Shackleton 1990; Brophy, Boland and Van Der Lingen 1992; Venter and Venter 1996; Geldenhuys 1997). On Sango Ranch, *Colophospermum mopane* shows the greatest potential for such harvesting. *Phragmites mauritianus* is also suitable for harvesting and is used for mats, furniture and in hut and fence construction (Van Der Walt 1999). This plant is abundant along the rivers on Sango Ranch. Its rapid growth rate makes it ideal for harvesting. However, it is important in the stabilisation of sandbanks and should therefore not be overharvested (Van der Walt 1999). *Hyphaene coriacea* is used for the making of palm wine (Cunningham 1990) and the leaves are used for the weaving of mats (Cunningham 1988). This plant does not occur in sufficient densities on Sango Ranch to allow commercial its harvesting. *C. mopane* is used for its timber which is hard and durable (Venter and Venter 1996). It is mainly used as fencing posts, hut poles, mine-props, railway sleepers and sometimes parquet flooring (Timberlake 1995). A survey of mopane in the Zambezi Valley of Zimbabwe, showed that there were few trees suitable for railway sleepers because most trees with a butt diameter of over 0.3 m had a timber height less than 3 m (Carter and Thompson, *In*: Timberlake 1995). Trees suitable for sleepers do however exist on Sango Ranch (Chapter 5). Most large trees have poor form, contain large knots and are often hollow because of heartwood rot (Palgrave 1956; Fanashawe 1962; Palmer and Pitman 1972; Wyk 1972; Pearce 1986; quoted in Timberlake 1995). *C. mopane* provides a good firewood and is a preferred species in areas where it occurs (Palmer and Pitman 1972, In: Timberlake 1995). The wood burns slowly and produces much heat and makes good charcoal. *C. mopane* is not used widely for medicine, but a bark extract is used to treat syphilis and sore eyes (Watt and Breyer-Brandwijk 1962). The seeds yield a hard resin termed gum copal, Angolan copal or basalm on extraction (Timberlake 1995). The yields are, however, low. Fifty different essential oils have been detected along with other compounds (Brophy *et al.* 1992). Other uses of *C. mopane* include soil stabilisation (Kumar and Shankarnarayan 1986, In: Timberlake 1995), making of twine and string and wood ash fertiliser (Palmer and Pitman 1972, In: Timberlake 1995). *C. mopane* occurs in sufficient densities to allow the harvesting of timber poles (Chapter 5).

Little information is available on the growth rates of natural stands of *C. mopane* (Timberlake 1995). In Botswana, Tietama (1989, *In:* Timberlake (1995), reported growth rates of 10 tonnes per ha per year. Scholes (1990) reported a basal area increment of 0.4 m^2 per ha per year for coppice growth in the Northern Province, South Africa. This area had been cleared of *C. mopane* shrub and thicket and had returned to a pre-clearing state within 14 years.

Smit (1994) investigated the influence of intensity of tree thinning on mopaneveld. Plots were thinned to 10 %, 20 %, 35 %, 50 % and 75 % of the standing density and were monitored over three seasons. Aspects investigated were population dynamics, structure, available biomass, grass cover, soil nutrients and soil water. Thinning of *C. mopane* reduced inter-tree competition that resulted in marked increases in the flowering and fruiting of remaining trees (Smit 1994; Smit and Rethman 1998). However, no evidence of faster seedling establishment on low-density plots was found. On a structural basis the trees showed increases in canopy cover rather than increases in tree height (Smit 1994). The available browse at peak biomass was reduced by tree thinning, but trees from the low density plots displayed a much better distribution of browse, having leaves in comparatively younger phenological states over an extended period. By cutting mopane trees and then allowing them to coppice, the amount of browsable leaves at low strata can be increased. However, this is undesirable when the manager aims to control bush encroachment and additional measures that kill the trees will have to be applied. Drastic colonisation of bare soil by herbaceous plants resulted with increasing intensity of tree thinning of *Colophospermum mopane*. Annual grasses were the main colonisers of bare soil in these areas with perennials only constituting a small percentage of the grass species composition. The successional order of establishing grasses was *Tragus berteronianus*, *Brachiaria deflexa* and *Aristida* spp. At high tree densities the *C. mopane* trees completely surpressed the grass layer with a resultant low grazing capacity. With an increase in tree thinning an increase in grass cover with an increase grazing capacity was noted. Of the soil variables investigated, few changed significantly as the result of tree thinning. An increase in potassium and a decline in electrical resistance were observed. In relation to increasing *C. mopane* densities, soil water penetration occurred to a shallower depth. Increased infiltration was associated with the establishment of a higher grass cover.

It is clear that severe *C. mopane* thinning can result in drastic changes in structure of the woody layer, and the cover and composition of the herbaceous layer. However, *C. mopane* stands are able to recover quickly after severe thinning (Scholes 1990). Because the management of Sango Ranch aims at maintaining the vegetation in its natural state, harvesting of *C. mopane* will have to be conducted at low intensities. Natural *C. mopane* stands can be thinned by 10 % without adversely affecting the population or resulting in vegetation change (Smit 1994). The

Thilachium africanum–Colophospermum mopane Short Thicket has the greatest *C. mopane* density and should be utilised for harvesting (Chapter 5). It is recommended that the size class required be thinned at not more than 10 % of the entire *C. mopane* population. To calculate the number of trees that can be harvested, take the 10 % of the density of the size class required for harvesting and multiply this density by 9 740 which is the size of the *Thilachium africanum–Colophospermum mopane* Short Thicket in ha. Permanent long-term monitoring plots in both harvested and unharvested areas should be established and species composition, structure, available browse, stem diameter distribution, reproduction dynamics, soil variables and soil water should be recorded. Rainfall should also be measured, since *C. mopane* recovery is affected by the amount of rain received (Scholes 1990). Smit (1994) did not investigated the effect of elephants on the tree layer. This should be investigated on Sango Ranch. Furthermore, harvesting should not be concentrated in a single area but be distributed over a large area so that thinning will not be evident to casual observation. Tree stumps should be allowed to coppice and these coppicing plants will begin to produce browse material, flowers and seeds at a browsable level for most browsers. Trials with coppicing in southern Zimbabwe have shown that 20 to 80 % of all the stumps have coppice shoots 3 months after cutting, and that trees coppiced at 1 m height produced more and taller coppice shoots than those cut at 100 mm height (Mushove and Makoni 1993, In: Timberlake 1995). The added advantage is that browse material will be brought into a lower level. It has also been found that production of poles from seedlings takes twice as long as production from coppice (Tietema *et al.* 1988, In: Timberlake 1995).

An important consideration in the harvesting of resources in natural systems is that harvesting be carried out in such a way as to ensure that rate of harvesting not exceed the rate of recruitment of new individuals (Geldenhuys 1997). The use of such resources for food and shelter by wild animals must also be considered.

MONITORING PROGRAMME

In extensive natural areas the outcome of a particular land-use or management strategy cannot be predicted with any degree of certainty because of the dynamic nature of ecosystems. Therefore, management must be applied and adjusted according to the current situation. Monitoring is essential to determine the extent to which specific management goals are realised (Joubert 1983). The techniques suggested for use are in compliance with the financial and human resources available on Sango Ranch.

Biotic factors

Vegetation

It is recommended that a total of 30 permanent plots should be established at representative sites within each of the management units identified during the phytosociological study. The plots are placed *pro rata* on the basis of the size of the management units. Plots are also placed at artificial waterpoints. The suggested co-ordinates of these plots appear in Table 56. The following dynamic components must be monitored at each of these plots:

1. Short, medium and long-term vegetation change

Fixed-point photography should be applied to identify short and medium term vegetation changes in the vegetation (Joubert 1983). At each point four colour photographs should be taken in the four directions of the compass around the fixed point. Photographs should be taken at each point every second year from August to September. Vertical aerial photographs should be used to complement the data derived from fixed-point photography. Large-scale colour vertical aerial photographs have been used successfully in the Kruger National Park (Joubert 1983). The method may deliver information on basal cover for the field layer and canopy cover regime for the woody plants; and help with the identification and subsequent monitoring of large samples of specific tree and shrub species.

2. Veld condition trend

Veld condition trends and grass species composition changes should be recorded by means of the method described in Chapter 6 for grass species composition and veld condition. Surveys should be carried out annually.

3. Changes in woody vegetation structure

Woody vegetation structure (density, cover, height) should be monitored annually as described in Chapter 5 using belt transects.

4. Seasonal and annual variations in herbaceous biomass

Table 56. The suggested co-ordinates for the permanent monitoring plots of the vegetation of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	*POINT*	*CO-ORDINATES*
Management Unit 1	1	20º 18.895' S 32º 05.661' E
	2	20º16.862' S 32º 15.148' E
	3	20º 15.020' S 32º 15.469' E
	4	20º 11.769'S 32º 02.622' E
	5	20º 19.225' S 32º 17.194' E
Management Unit 2	6	20º 12.065' S 32º 06.181' E
	7	20º 18.995' S 32º 16.461' E
	8	20º 14.910' S 32º 12.526' E
	9	20º 12.617' S 32º 08.130' E
	10	20º 10.376' S 32º 09.954' E
	11	20º 14.677' S 23º 06.028' E
	12	20º 21.303' S 32º 13.465' E
	13	20º 15.562' S 32º 08.120' E
	14	20º 18.910' S 32º 14.245' E
	15	20º 12.625' S 32º 07.585' E
	16	20º 18.125' S 32º 04.671' E
	17	20º 12.076' S 32º 07.795' E
	18	20º 15.407' S 32º 00.379' E
	19	20º 13.231' S 32º 04.763' E
	20	20º 17.567' S 32º 11.722' E
Management Unit 3	21	20º 10.564' S 32º 06.136' E
	22	20º 14.598' S 32º 04.728' E
	23	20º 11.064' S 32º 03.165' E
	24	20º 17.208' S 32º 02.378' E
	25	20º 15.446' S 32º 07.291' E
	26	20º 10.447' S 32º 01.816' E
	27	20º 17.930' S 32º 00.426' E
Management Unit 4	28	20º 17.023' S 32º 17.880' E
	29	20º 19.738' S 32º 17.540' E
Management Unit 5	30	20º 16.733' S 32º 18.500' E
	31	20º 14.999' S 32º 19.004' E
Management Unit 6	32 Masiyauta Pan	20º 15.467' S 32º 10.143' E
	33 Sune Pan	20º 21.620' S 32º 16.006' E

Herbaceous biomass should be measured annually just before the commencement of the growing season. By also measuring herbaceous biomass at the beginning of the growing season one can determine grass production. Herbaceous biomass should be monitored by means of the disc-pasture meter as described in Chapter 7. Exclosures should be used to determine grazing pressure by herbivores.

5. Available browse and ecological capacity

Because the ecological capacity varies with climate, it should be monitored annually using the techniques described in Chapters 8 and 9.

Large herbivores

Annual aerial surveys should be conducted during the dry season when most of the large water-dependent herbivores are found near water and when the vegetation structure is open. These surveys will yield information on trends in density, spatial distribution and social organisation. Additional information on age and sex structure and animal condition can be obtained by means of road strip counts as given by Mason (1990). Hunting provides a convenient method of monitoring animal condition. Hunted animals can be checked for condition using the techniques described by Ebedes (1995).

Predator-prey relations

The presence of large predators in the area poses several problems. Predators may have severe effects on the rarer prey species such as sable antelope (Mills 1991). The larger predators often have a negative influence on the smaller rarer predators such as the cheetah *Acinonyx jubatus*, black-backed jackal *Canis mesomelas*, leopard *Panthera pardus* and wild dog *Lycaon pictus*. Predators also often come into conflict with man (Anderson 1981; Stander 1990; Mills 1991; Scheepers and Venzke 1995). Lions and spotted hyaenas have the greatest impact because of their high density (Smuts 1982). On Sango Ranch, where no lions occur and hyaenas are at a low density, the impact from these predators should be minimal. Where possible, predator numbers and prey use should be monitored to determine predator-prey relations.

Abiotic factors

Daily, seasonal and annual variations in the climate should be monitored. Several recording stations are recommended at key points to record at least rthe ainfall and minimum and maximum temperatures. These points should be representative of variations in altitude within Sango Ranch. Stations should be established at headquarters, at the Save River house and at Ingwe Lodge as shown in Figure 3.

General factors

Various abiotic and biotic environmental variables should also be recorded at each permanent plot together with the veld condition, herbaceous biomass and fixed-point photographs, namely:

1. Degree of erosion.
2. Type of erosion.
3. Degree of trampling.
4. Degree of utilisation of the herbaceous layer.
5. Intensity of a burn separately for the herbaceous and woody layers.
6. Height of herbaceous layer.
7. Canopy cover separately for woody and herbaceous layers.
8. Phenology separately for woody and herbaceous layers.
9. Proportion of green material as a percentage of all the plant material available.
10. Amount of litter.

The degree and type of erosion should be monitored throughout Sango Ranch, and not only at the monitoring plots.