REPORT 9B

PEEL, MJ. VILANCULOS COASTAL WILDLIFE SANCTUARY.

1. INTRODUCTION

1.1 Terms of reference

This report is aimed at providing the following for the Vilanculos Coastal Wildlife Sanctuary (VCWS):

1) To provide initial carrying capacity guidelines for the VCWS as part of a planned wildlife re-introduction program based on veld assessments;
2) From the above to propose a three step approach (Phase 1 Part 1, Phase 1 complete and Phase 2) to introducing herbivore species as well as the numbers to be introduced at each time; and
3) To incorporate the findings of this report into the Biodiversity Management Plan which will include appropriate management guidelines.

The report describes the methods employed in the assessment of the Phase 1 area (the field assessment was done with the assistance of Marc Stalmans who also took the photographs) followed by a results and discussion section. The final section provides guidelines for the re-introduction of herbivores into the terrestrial part of the VCWS. This includes (sizes Lambrechts *pers comm.*):

1) Re-introduction guidelines for herbivore species for Phase 1 part 1 (8 500ha);
2) Re-introduction guidelines for herbivore species for Phase 1 complete (22 000ha); and
3) Re-introduction guidelines for herbivore species for Phases 1 and 2 (39 000ha).

A field assessment of veld condition was done during a five-day visit to the VCWS during May 2002. An overflight of the area was done during a subsequent trip.

1.2 Vilanculos Coastal Wildlife Sanctuary

The VCWS is located in the Inhambane Province of Mozambique. The proposed size of the sanctuary is 30 000ha (First Phase – terrestrial 22 000ha) and 17 000ha (Second Phase - terrestrial)(Lambrechts *pers comm.)*. The San Sebastian Peninsula forms the major portion of the VCWS. The peninsula is dominated by miombo Woodland interspersed with a diversity of habitats that include wetlands, freshwater lakes, tidal mudflats, salt marshes and mangrove swamps. The marine area includes estuaries, a sand peninsula barrier along the seaward boundary of the Inhambane Estuary, islands, and coral reefs (Lambrechts 2001).

1.3 Ecological Issues

1.3.1 The impact of man

Observations made during the field visit indicate that man has been linked to the VCWS area for a long time. Although human densities are relatively low in the VCWS the impacts are none the less marked. Households depend on natural products obtained from the woodlands and grasslands. These take the form of fuelwood, timber, thatching grass, fruit and mushrooms among others. In addition to this it is evident that the marine ecosystem is an important resource for the people living here.

Slash-and-burn (ash fertilisation) agriculture is widely practised in the VCWS. The practice is common in the low-fertility miombo soils particularly in wetter regions (such as VCWS) where woody plant biomass is high and cut trees regenerate rapidly through resprouting (Desanker, Frost, Frost, Justice & Schole 1997)(Figure 1). The foliage and branches of trees are cut and stacked whereafter they are allowed to dry out before being burned. By concentrating the brush into large piles a deeper bed of ash and greater fertility is achieved (especially important where livestock numbers are low as VCWS). The land is cultivated until the enhanced fertility is exhausted or until the regenerating woody vegetation and weeds make cultivation unproductive (Desanker *et. al* 1997). The plot is then abandoned and new areas are opened up (Figure 1).

Relatively large areas of miombo have been and continue to be transformed by people in the VCWS.

1.3.2 The impact of animals

The nutrient content of the foliage of miombo plants is generally low. The Nitrogen content of mature leaves of non-nodulated canopy tree species is significantly lower than that of the few

Figure 1 Illustration of stages of re-generation of miombo Woodland in the VCWS. Top left showing higher successional stage in the background to re-generating miombo (middle ground) to currently cultivated (foreground). Top right illustrates the same successional stages but note in particular the wood stacked up in the centre and ready to be burned. Bottom centre shows a close up of a stack of wood to be burnt.

nodulated N-fixing species (Desanker *et al*. 1997). In addition to this the grass nutritional quality is even lower than that of woody leaves for much of the year, and is in fact below the approximate level required to maintain grazing ungulates (Desanker *et al*. 1997). This is a major constraint to herbivorous animals in the absence of supplementary feeding.

Caution should therefore be the watchword when re-introducing large wild herbivores into the VCWS system. The biomass of indigenous large herbivores in conservation areas in other miombo woodlands is only about 20-30% of that expected at the same mean annual rainfall in African ecosystems with nutrient-rich soils (Desanker *et al.* 1997 and as given in Coe *et al.* 1976, Bell 1982 and Fritz & Duncan 1994). Specialist ungulate browsers are rare in these habitats and much of the biomass is normally made up of large bodied species such as elephant and buffalo and other grazers such as sable antelope.

However large herbivores such as elephant, white rhino, buffalo, and zebra have the ability to bring about drastic changes in unutilised climax vegetation, and are termed Type I feeders (Collinson & Goodman 1982). Species which decrease due to changes brought about by Type I feeders are termed Type II feeders and include roan, sable, tsessebe and waterbuck (Collinson & Goodman 1982). The latter species, which require relatively open areas with nearby thickets for shelter, do not cause substantial change to vegetation composition and structure (Collinson & Goodman 1982). Species which increase in response to Type I utilisation are termed Type III herbivores and include wildebeest and impala. Type III feeders have the ability to push the vegetation state induced by Type I feeders past the threshold point which would have resulted had Type III feeders been absent (Collinson & Goodman 1982). Type IV feeders may increase due to changes brought about by Type I and III species, but have little impact on the vegetation (Collinson & Goodman 1982). Examples of Type IV feeders include giraffe, kudu, black rhino, eland, and bushbuck.

The basal metabolism (animal at rest) is inversely proportional to body mass. Smaller animals, made up mostly of Type III and Type IV feeders have higher metabolic rates, higher relative maintenance requirements and lower absolute requirements than larger animals. They therefore have a high intake, select a diet of high nutritive value and have a high digestive efficiency. Furthermore, the effects of herbivory on the habitat include a reduction in plant and litter cover, reduced fire probability, reduced fire intensity, nutrient enrichment through dung and urine, soil compaction, trampling, reduced infiltration, increased runoff, and increased erosion on certain soils (Collinson & Goodman 1982). This is particularly important in areas where animal movement is restricted by fencing. Herbivory results in compensatory growth by plants in the following ways:

1) Under conditions of low defoliation, the plants compensate by just replacing lost tissue;
2) Under moderate levels of defoliation and favourable moisture and nutrient conditions, overcompensation, with a resultant increase in plant production, may occur (McNaughton 1985); and
3) Under severe defoliation regrowth does not compensate and, if continued, causes desirable species to diminish while facilitating the establishment of those species resistant to herbivory increase (Frost *et al.* 1986).

The term ‘carrying capacity’ is a nebulous one, with many definitions and is difficult to determine in heterogeneous environments experiencing variable environmental and resource conditions. The Large Stock Unit (LSU) has to date formed the basis of expression of ‘stocking rate’ and ‘carrying capacity’. The LSU uses the animal’s metabolic energy requirements and probable food intake, and comparisons between animals are generated and expressed as LSU’s (Meissner 1982). While the principles of this approach are valid and useful under certain circumstances (e.g. a single-herbivore cattle grazing system), the LSU is based on a heavy-bodied grazing ruminant (originally a 1 000 lb. ox!) and does not take into account the feeding patterns (overlap) and digestive systems of different herbivores. In multi-herbivore systems this leads to confusion when calculating carrying capacity and stocking rates. Furthermore, the term ha LSU^{-1} assumes that systems tend to equilibrium (assuming stability and homogeneity). There are a number of additional shortcomings:

1) The term indicates a decrease in magnitude with increasing livestock numbers (Danckwerts & Stuart-Hill undated). This is misleading and is contrary to the SI units system of nomenclature (Savage 1979; Taylor 1991);
2) Stocking rate is also an expression of the number of animals per unit area and the units must reflect this, i.e. LSU ha^{-1}. In fact, as the word 'rate' is used, a time dimension is presupposed so that LSU ha^{-1} are the units for stocking density and LSU ha^{-1} a^{-1} are the correct units for stocking rate (Peel *et al.* 1999); and
3) The term is not linearly related to the number of animal units on an area of land (Danckwerts & Stuart-Hill undated).

An alternative approach was proposed by Coe, Cumming & Phillipson (1976) who related the **biomass** of animals carried on game areas to long term annual rainfall. The formula uses the mean animal mass of herbivores where the biomass making up the animal component are summed for an area. The model importantly provides a range stocking densities for a given long-term mean annual rainfall. This allows management to take into account resource conditions at a variety of spatial and temporal scales (although this is not actually provided by Coe *et al.* (1976)).

The carrying capacity of an area is taken as the sum of its grazing and browsing capacities (Danckwerts & Stuart-Hill undated). The exact diets of animals are debatable and the point of their division arbitrary. A model proposed by Collinson & Goodman (1982) divided herbivores into the following four classes:

1) Primarily grazers (90 - 100%) feeding on medium to tall grass of moderate quality (bulk grazers);
2) Primarily grazers (90 - 100%) feeding on short grass of high quality (concentrate grazers);
3) Mixed feeders (11 - 89%) feeding on grass; and
4) Primarily browsers (90 - 100%) feeding on the woody component.

Collinson & Goodman (1982) further recommended a species mix ratio of 45%:20%:20%:15% for classes 1 to 4 respectively.

For the VCWS t**he biomass and feeding class method, where stocking rates and species mix ratios are adjusted in accordance with rainfall and veld condition is proposed.**

1.3.3 System functioning

The dynamics of miombo has been variously described but the description by Freson *et al.* 1974 who proposes a three-stage regressive series (dense dry forest-open miombo woodland-savanna) induced by the combination of woodcutting and fire seems to reflect the current situation in the VCWS. These multi-state models should be investigated as part of the envisaged research programme (Management Plan *in prep*). Such studies should investigate multi-state models where following the abandonment of cultivated fields (or combined impacts of clearing (by man or animals e.g. elephants) and fire there is a transition to open woodland. Fire is considered to be the driving force behind transitions (with a longer than normal fire-free period to return to miombo dominated woodland)(Stromgaard 1986).

In terms of management options, it must be borne in mind that the VCWS system contains sizeable areas of higher potential "depressions" consisting of more palatable and productive grasses. Small pockets of *Acacia* and *Commiphora* woodland are also present.

At the outset therefore it is imperative that a clear set of conservation objectives be set from which management goals may be defined (Management Plan *in prep.*).

2. METHODS

2.1 Approach

The field visit aimed at learning as much about the area in terms of the ecosystem functioning and land-uses as possible. The visit was used to effectively assess the system for the introduction of herbivores. A detailed description of the terrestrial area is currently being prepared (Jacobsen and Tarboten *in prep.).*

2.2 Field Procedure

Five days were spent at the sanctuary, the first day was spent driving over as much of the area as possible with the resident scientist to get a general feel for the area. The remaining four days were spent assessing the landscape with a view to determining rangeland condition and large herbivore carrying capacity. During this time there was ongoing consultation with sanctuary staff as well as a meeting with Chief Sinave regarding the previous distribution of animals in the area. 121 sites were randomly selected for assessment during driving/walking transects (Figure 2). A flight of approximately 40 minutes duration was done to reconnoiter the area. Particular attention was given to the inaccessible southern areas.

2.2.1 The vegetation assessment

Vegetation type based on the dominant tree and grass species and land-unit type (a broad structural classification of vegetation after Edwards (1983)) are important in determining suitable habitat for the species earmarked for re-introduction.

Soil moisture availability and soil nutrient status are critical in determining the structure and functioning of savanna systems in that they affect the balance between trees and grasses and patterns of primary production and plant quality (Frost *et al.* 1986). The latter influence the kinds and extent of herbivory, animal impacts, and fire frequency and intensity which in turn affects soil moisture and nutrient availability. Sandy soils such as those that dominate in the VCWS allow rapid infiltration and percolation through the soil profile thus minimising evaporation through the soil surface (O’Connor 1985). Sandy soils have a potentially lower water holding capacity than clay soils but most of the moisture present is available to plants. Sandy soils also show less fluctuation in plant available moisture between seasons because they hold higher proportions of soil moisture than clay soils (O’Connor 1985).

It has been shown that as grass canopy cover decreases, so soil loss and rainfall run-off increase markedly. As the cover falls below about 25% so the surface run-off increases exponentially.

Grass tuft size and vigour may vary markedly within species and are important measurements that provide information on the stability, resilience and competitive status of species within the grass layer and between grasses and trees.

Utilisation and grass standing crop is an extremely important issue in rangeland management. The grass layer can be kept in a vigorous condition as long as it is utilised in a way that allows it to grow and reproduce. Major changes in vegetation are often caused by the interactive influence

REFER TO VOLUME 2 OF THE BMP FOR THE FIGURES

insertFIGURE 2).

of herbivory and fire. Herbivory interacts with fire spatially and temporally, with grazers being attracted to newly burned areas. Grazers in turn reduce fuel loads resulting in a lower probability of the area sustaining another burn. Herbivory is usually specific and confined to certain favoured plant species and parts, and herbivore impact tends to be restricted in space but is more uniformly distributed in time (Frost *et al.* 1986). Fire on the other hand is periodic, can potentially extend over a large area, and is non-selective.

The following vegetation parameters were measured per site:

1) Site number and Global Positioning System (GPS);
2) Vegetation type and land-unit (Appendix A) was recorded at each site. This allowed for an approximation of the proportional contribution of the various veld types and land –units identified in the VCWS;
3) Soil conditions (litter, erosion, capping, pedestals, compaction);
4) Grass-cover was estimated on a six point scale (modified after Mueller-Dombois & Ellenberg 1974) on a continuum from 0.5%, 3%, 15.5%, 38%, 62.5% to 88%;
5) Tuft size and vigour were estimated on a three point scale (1<50mm, 50-100mm and >100mm) and five point scale (1=low to 5=high) respectively; and
6) Uutilisation and standing crop were estimated on a four point scale (1=low to 4 = high) and eight point scale (1<500kgha^{-1}, 2=500-1 000 kgha^{-1}, 3=1 001-1 500 kgha^{-1}, 4=1 501-2 000 kgha^{-1}, 5=2 001-2 500 kgha^{-1}, 6=2 501-3 000 kgha^{-1}, 7=3 001-3 500 kgha^{-1} and 8>3 500 kgha^{-1}) respectively.

2.2.2 Herbivore suitability assessment

In multi-species systems it is important to determine the proportional contribution of herbivore species to the total stocking rate. Decisions in this regard considered the following for the species proposed for re-introduction (based on Collinson & Goodman 1982):

1) The objectives of the Sanctuary;
2) The type and proportion of forage available; and
3) The feeding habits of the species in question.

The following was estimated per site for animals that occurred in the area historically and those that would adapt to the conditions at VCWS:

1) Habitat suitability based on a five-point scale (1=very low to 5=very high).

2.2.3 A preliminary assessment of the carrying capacity of the VCWS

Grossman (1984) describes ecological carrying capacity as the population size of an organism in an area as determined by the capacity of that area to support the individuals in that population and enable them to reproduce. Economic carrying capacity is the number of animal units per unit area of land which will achieve maximum animal production per unit input, but does not permit soil erosion or changes in the botanical composition that reduces the potential of the vegetation to produce animal products (Danckwerts 1982).

As discussed under section 1.3.2, the biomass method, where stocking rates are adjusted in accordance with rainfall is currently being used in this study, as is the division of herbivores into four feeding classes. The guidelines and limits will be refined for the study area during the planned monitoring process.

A herbivore carrying capacity map was constructed using a Landsat Thematic Mapper satellite image. The latter represents a degraded image with a pixel size of 100 x 100 m compared to the original (and finer) 30 x 30 m pixel. A step-wise approach was followed to identify areas of different carrying capacity.

Firstly, the three spectral bands from the image were imported into the IDRISI Geographical Information System. A composite image of the three bands was generated. This composite was subjected to an unsupervised classification using a histogram peak technique of cluster analysis (Eastman 1992). Unsupervised classification allocates each pixel to a certain class based on its spectral characteristics only. No *a priori* assumptions are made regarding the information content of the LANDSAT image or of the classification clusters. For an unsupervised classification, no existing information on the ground situation is needed.

Secondly, the GPS (Global Positioning System) coordinates of each of 121 field samples were imported into the GIS. For ease of presentation, the field sites were divided into three different groups; those representing low carrying capacity (≤2 250kgkm^{-2} or expressed otherwise ≤5 LSU100ha^{-1}), as estimated in the field), medium carrying capacity (>2 250kgkm^{-2} to 4 050kgkm^{-2} or >5 LSU100ha^{-1} to 9 LSU100ha^{-1}) and high carrying capacity (>4 050kgkm^{-2} to 4 500kgkm^{-2} or between 9 LSU100ha^{-1} and 10 LSU100ha^{-1}).

The meaning of the clusters of the classified image was then explored using those GPS positions. The correspondence of the position of the field samples with different carrying capacity relative to the different clusters was used to assign a value of low, medium or high carrying capacity to the map. The clusters were then reclassified and lumped into three categories (low, medium and high carrying capacity respectively).

Finally, the marshy depressions, which were identified in the field as being of higher carrying capacity, were subjectively delineated on the satellite image. Their perimeter was superimposed on the map with the three different carrying capacity classes. This effectively increased the extent of the area with a high carrying capacity.

The following was done on site:

1) An estimate of stocking densities per site ranging from 1 125 kgkm^{-2} (2.9 LSU100ha^{-1}), 1 500 kgkm^{-2} (3.3 LSU100ha^{-1}), 1 800 kgkm^{-2} (4 LSU100ha^{-1}), 2 250 kgkm^{-2} (5 LSU100ha^{-1}), 3 000 kgkm^{-2} (6.7 LSU100ha^{-1}), 4 500kgkm^{-2} (10 LSU100ha^{-1});

2) A broad guideline estimate based on the approach of Coe *et al.* 1976 (providing a range of estimates); and

3) The herbivore carrying capacity map constructed.

3. Results, Discussion and Recommendations

3.1 VCWS Objectives

The following needs to be stated briefly here and discussed in detail by Lambrechts (2001).

3.1.1 Reasons for establishment

The mission of the project is "To effectively conserve the unique and fragile natural marine and terrestrial resources of the VCWS, and to sustainably utilise these resources by means of low intensity, rigidly controlled and environmentally sensitive commercial development to the benefit of the local communities and the investors".

3.2.2 Possible ecological objectives (terrestrial and marine biodiversity) and objectives dictated by prevailing circumstances

1) To conserve a wide diversity of indigenous species and their associated habitats using sustainable utilisation principles;
2) Conserve a wide diversity of indigenous species as a base for outdoor recreation;
3) Facilitate the sustainable utilisation of the natural resources in the reserve for the long term social and economic benefit of the land owners and communities in the vicinity of the VCWS; and
4) Support rural development by stimulating the local economy through the provision of suitable opportunities for entrepreneurship and employment and by initiating and participating in community-based projects using natural resources derived from sustainable utilisation programmes

To achieve the above management goals need to be articulated (Management Plan *in prep.)*.

3.2 Vegetation Type and Land Unit

Freson *et al.* 1974 proposed a three-stage regressive series for miombo (dense dry forest-open miombo woodland-savanna). For completeness two stages, re-generating miombo woodland and currently cultivated lands were added to this classification (Figure 3a). As previously mentioned, an important component in the VCWS system are the so-called “depressions” which have a much higher carrying capacity than the surrounding miombo, while the small areas of *Commiphora*, *Acacia*, salt marshes and Thickets will also attract the attention of mixed feeders and browsing herbivores (Figure 3b). Figure 3b also illustrates the sensitive mangrove habitats.

Figure 3a Illustration of main forms of miombo Woodland in the VCWS. Clockwise from Top left - Dense dry forest, Savanna, open miombo woodland, re-generating miombo woodland and currently cultivated lands.

(INSERT FIGURE 3)

Tables 1 and 2 broadly classify the VCWS into vegetation types and land-units (structural).

Table 1 A preliminary description of vegetation types in the VCWS.

Broad Veld Type description	As percentage of sites assessed (%)
1) Miombo woodland	60
2) Depression/Pan areas	12
3) Cultivated areas	2
4) Regenerating miombo woodland	20
5) Thickets	3
6) Mangrove	1
7) Acacia veld	1
8) Salt Marsh	1

Table 2 A preliminary description of the land-units found on VCWS (Appendix A for explanation).

Land-Unit	As percentage of sites assessed (%)
113) Short forest	4
114) Low forest	10
122) Tall closed woodland	2
123) Short closed woodland	7
124) Low closed woodland	25
133) Short open woodland	1
134) Low open woodland	6
211) Short thicket	2
212) Low thicket	18
222) Low bushland	2
311) High closed shrubland	1
312) Tall closed shrubland	5

322) Tall open shrubland	2
332) Tall sparse shrubland	1
411) High closed grassland	1
412) Tall closed grassland	4
413) Short closed grassland	1
414) Low closed grassland	5
434) Low sparse grassland	2
511) Tall closed herbland	1

3.3 Grass cover

The grass cover is generally moderate for VCWS (Figure 4). The miombo can be said to be a typical moist-dystrophic savanna (Huntley 1982; Frost *et al.* 1986). As herbaceous cover decreases so soil loss and rainfall run-off increases. Herbaceous cover is therefore important in sandy soils such as those found on VCWS.

3.4 Tuft vigour

The tuft vigour for VCWS is, as expected on dystrophic soils, generally low (Figure 5).

3.5 Grass standing crop

The grass standing crop can be said to relatively low for VCWS with most sites having between 250 and 750kg/ha (Figure 6). Grass biomass is the biomass of grasses, forbs and sedges, i.e. the non-woody component of the vegetation. It is important because it indicates how much food is available for grazers, how much material there is for utilisation by man and how much material there is for burning. Grass standing crop is a crude measurement as not all species are acceptable to herbivores so it is combined with composition, structure and vigour estimates to indicate the amounts of acceptable forage available for grazers.

3.6 Habitat suitability for large herbivores in VCWS

Habitat suitability assessments are illustrated per Feeding Type below (Figures 7-10). For an explanation of feeding types refer to Section 1.3.2. It can be seen that the habitat suitability is largely low to very low. This corroborates the findings of the both the vegetation and carrying capacity assessments.

3.7 Carrying capacity assessments for VCWS

Whatever the objective decided upon for VCWS (probably aimed at ecological carrying capacity) results indicate that the area has a low herbivore carrying capacity (Figures 11 and 12).

Observations of grass conditions in VCWS:

Figure 4 (top) Frequency distribution of grass cover;

Figure 5 (middle) Frequency distribution of tuft vigour; and

Figure 6 (bottom) Frequency distribution of grass standing crop.

Habitat suitability for herbivore feeding types on VCWS:

Figure 7 Habitat suitability potential for Type I Feeders on VCWS (top 5 graphs); and

Figure 8 Habitat suitability potential for Type II Feeders on VCWS (bottom 3 graphs).

Habitat suitability for herbivore feeding types on VCWS:

Figure 9 Habitat suitability potential for Type III Feeders on VCWS (top graph); and

Figure 10 Habitat suitability potential for Type IV Feeders on VCWS (bottom 3 graphs).

Figure 11 Frequency distribution classified image of carrying capacity for VCWS.

Where: Frequency distribution classified image:

Yellow = very low carrying capacity 44.6%

Dark blue = low 44.7%

Green = moderate-high (depressions) 10.6%

Figure 12 Frequency distribution of stocking rate estimates for VCWS.

3.8 Guidelines for large herbivore re-introduction

Due to the inherently low carrying capacity of the area, it is probable that large herbivores were never permanently resident in the VCWS. The fencing off of some 8 500ha as part of the first phase of the Sanctuary development and the proposed introduction of large herbivores into this "closed" system therefore presents a unique set of challenges. Management is presented with an opportunity to, as it were, "start from scratch". Given the limited knowledge that we have of how the ecosystem will respond to the introduction of large wild herbivores it is recommended that the initial introductions should be conservative.

Keeping the objectives of the Sanctuary in mind, introductions should be aimed at:

1) Re-establishing wild herbivores which, according to available historical evidence, occurred in the area ;
2) To prioritise the introduction of populations of "drawcard" species (e.g. elephant – but in line with point 1);
3) To maintain other species in densities that do not compromise the success of the "drawcard" species;
4) To maintain all populations at numbers, sex and age structures and proportions which will not compromise the vegetation, soil and hydrological integrity of the VCWS;
5) Given the low numbers of animals that are to be introduced, consideration will need to be given to maintaining the genetic diversity of the re-introduced large herbivore populations and some selective swapping out of animals of will require consideration in the future;

6) To obtain revenues from the utilisation of surplus herbivores for the benefit of the surrounding rural communities.

The above is given in order of priority after Collinson & Goodman (1982).

3.9 Animal introductions

The following must be noted:

1) The biomass density of miombo woodlands is only about 20-30% of that expected in areas receiving similar rainfall on nutrient rich soils. This was confirmed in the current survey;
2) The initial introductions should be conservative; and
3) **The numbers are based on the assumption that Phase 2 contains similar habitat to the surveyed Phase 1 area since no visit to the Phase 2 area was possible.**

In order to achieve the ecological objectives, the reserve should initially be stocked at low levels. A three-phase approach is proposed:

1) **The initial introduction of mainly small and medium sized "non-dangerous" species into the area that is currently being fenced (Phase 1 Part 1 – 8 500ha) allowing for safe walks within this area. The introduction of buffalo in this part of the reintroduction has been included in the calculations but the presence of people in the area must be considered;**
2) **The introduction of large herbivores such as elephant and hippo (Phase 1 complete – 22 000ha Lamprecht *pers. comm.*). In addition to the latter species, guideline figures are given for the other species that were introduced during Phase 1 Part 1 (i.e. these are not natural increments but are considered sound when related to the increased size of the area). Regarding elephant, hippo and buffalo the issue of people within the fenced area requires attention;**
3) **The initial numbers that may be present after completion of Phase 1 and 2 (39 000ha – Lambrechts *pers. comm.*); and**

4) **The approach taken should be subject to an adaptive management philosophy. The slow build up of animals (particularly species such as elephant, buffalo and hippo – Type I feeders) towards those given in Table 3 in conjunction with a comprehensive monitoring programme is essential. Management action must be implemented in the event of any signs of habitat degradation.**

Table 3 A guideline for herbivore numbers for the initial phases for VCWS (no natural increments included).

Herbivore species	Phase 1 part 1 – 8 500ha	Phase 1 complete - 22 000ha	Phase 1and 2 complete – 39 000ha
Zebra[1]	20	52	92
Buffalo	25	65	115
Waterbuck	20	52	92
Lichtenstein's Hartebeest	15	39	69
Nyala	20	52	92
Reedbuck	20	52	92
Sable	15	39	69
Bushpig	10	26	46
Hippo		12	21
Elephant		20	35

[1]If suitable animals can be found (Grobler *pers comm.)*; Caution in re-introducing buffalo, elephant and hippo with people present in the Sanctuary.

Figure 13 illustrates the stocking rates obtained from the above numbers (note again these are absolute numbers and are not the result of natural increases in the populations

presented). The median stocking rate obtained from the assessment was 1 800kgkm^{-2} (as stated above it is proposed that the Sanctuary not be stocked initially at this rate and that the numbers be allowed to build while carefully monitoring the response of the vegetation to re-introduced herbivores). This is in broad agreement with the figure obtained using Coe *et al.* 1976 (although the rainfall is slightly above the range used in these systems). A scenario is sketched where the natural increase of animals is estimated for Phase 1 (part 1) for four years after the initial re-introduction (with the introduction of eight elephant and six hippo in the

Figure 13 Projected stocking rates taken from the numbers given in the above Table.
With approximations given in LSU terms below: Phase 1 (part 1) stocking rate is 0.8LSU/100ha = 64LSU; Phase 1 complete stocking rate is 1.7LSU/100ha = 367LSU; and Phase 1 and 2 stocking rate is 1.7LSU/100ha = 650LSU.
second year n+1) (Appendix B - top). Note the relatively quick population growth towards the range of guideline stocking rate estimates because of sufficient resources for the animals to reproduce at optimal rates (and the importance of introducing sex and age structures that will facilitate such increases). This principle is illustrated in Appendix B (bottom). The cautious approach to re-introduction and subsequent game population growth would allow for the resource monitoring programme to determine the impact of the re-introduction's on the resource. This would in turn support the adaptive management approach to management where opportunities are grasped and hazards avoided.

In addition to this the first phase introduction scenario animals such as Duiker (Red and Grey), Oribi and Suni could be safely introduced (depending on availability).

3.10 Future management, monitoring and research programme

Whatever the decision regarding re-introductions, there will have to be a comprehensive monitoring programme in place based on the following:

1. Threshold's of Probable Concern (TPC's) (concept discussed in Management Plan in prep.):
   - **Hypotheses** of the spatial and temporal limits of natural ecosystem flux;
   - Provide **amber lights** for both scientists and managers – This facilitates improved understanding and considered action;
   - Described by upper and lower limits of change in selected ecological **indicators;** and
   - TPC's are derived from work such as done in this survey (best-available-data basis).

2. TPC's would therefore be based on system health indicators and will include:

- Rainfall;
- Geology/soil;
- Vegetation classification (plus Normalised Difference Vegetation Index NDVI’s and Moving Standard Deviation Index MSDI’s);
- Range assessment data;
- Nutritional status of herbivores

From 1 and 2 above animal numbers and species mixes would be first set and then adjusted accordingly and when appropriate. The numbers presented above must therefore be taken as a first approximate. As the monitoring research programme starts providing information regarding animal impact/success management may find that certain initial guidelines may be adjusted upwards or downwards. Thus an adaptive management approach to VCWS management is advocated.

4. References and other reading

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Appendix A

A broad-scale structural classification used in VCWS (after Edwards 1983).

Appendix B

Top - Population growth scenario using Phase 1 part 1 as an example; and Bottom - A hypothetical population growth curve of a game population.