“The destruction caused by elephant” is a term loosely used in the elephant debate. This powerful term creates a mix of emotions towards elephants and the role they play in our ecosystem. Therefore before we can start to manage elephant we need to untangle the complex system in which they are found and what the management objectives are for that system. An article written in 2008 by Dan Parker and Ric Bernard on the current disappearance of aloes in the new section of Addo National Park, where elephants have recently only been allowed back into the section, stated “Over 100 years, the loss of aloes could be interpreted as serious damage, whereas over a millennium it may well be a return to a more natural state. Let us not forget the observation by Lewin: ‘On the larger scale of things, change within ecosystems should therefore be seen as natural and inevitable, even if it sometimes leads to local extinctions.’(Lewin 1986). This statement reminds us that change in inevitable and not always a negative thing.

Science has had to make a Paradigm shift from believing in the “balance of nature” to the “flux of nature” (Pienaar 2004) as thousands of minor and major events occur daily in an open system; they each contribute in their own unique way to the ebb and flow of ecological processes. Ultimately as custodians of the reserve the goal is to understand the creation, the maintenance or the change in heterogeneity while still maintaining biodiversity. In 2003 Sanparks took on this approach and created the Threshold of Potential Concern (TPC), the use of these thresholds allows management to maintain an adaptive management style whilst still ensuring systems stay within an acceptable range of flux. What are Thresholds of Potential Concern?

TPC’s are a set of operational goals that together define the spatiotemporal heterogeneity conditions for which the Kruger ecosystem is managed. TPC’s are essentially upper and lower limits along a continuum of change in selected environmental indicators (Fig 1). The suite of TPC’s together represents the envelope within which ecosystem changes are considered desirable (Biggs et al 2003). When the indicators come close to Max or Min or modelling suggests these limits will be reached in the near future the management is set out to assess the situation.

This assessment provides the basis for deciding whether management action is needed to moderate the change or whether the TPC should be recalibrated in the light of new knowledge and/or understanding. TPC’s form the basis of an inductive approach to adaptive management because they are hypotheses of limits of acceptable change in ecosystem
structure, function and composition (Biggs et al. 2003). These limits are not set and should regularly be investigated and adjusted according to new findings and objectives. The actual limit is less important than the rate at which a situation is approaching the thresholds. By reacting to high rate situations necessary management actions can be made timeously.

![Figure 1 Concept of TPC's and the desirable zone which falls within the Max and Min limits (Biggs et al 2003)](image)

TPC’s are derived directly from the objectives of the institution which are set out in the Management Plan. These TPC’s need to be set on sound ecological knowledge and applicable data or scenarios for the area. For each TPC a hypothesis that can be tested as well as a record of all concerns must be narrated so that intentions are clearly stated for when TPC’s are revisited. The use of TPC’s requires monitoring programs to input data in the Hypotheses or models. Current monitoring programs should be used for initial inputs. Any necessary additional programs should complement current programs to ensure hypothesis testing is equally significant over time.

The primary objective of the properties that constitute the SSW is to provide for ecologically and aesthetically sustainable (non-consumptive and consumptive) use of the area for its owners, based on wildlife focused recreation and tourism (SSW management Plan 2012)

The term Management referred to in the following pages is the collective custodians of the SSW, including land owners, property managers and SSW management. When referring to the SSW as an ecological entity this includes Mala Mala as they form part of the ecological unit on which all historical data is based on. Although management of the SSW has no authority over Mala Mala it is still an integral part of the system and must be included.
The following questions must be asked to highlight the roles of TPC’s

1. “Perceived” change versus “recorded” change
2. Structure versus function.
3. Importance of the issue and with this the willingness to make changes
4. Future effects if nothing is done
5. Effects on other species
6. Scale at which we want to do things

“Perceived” change versus “recorded” change

The perceptions of what is going on can often be skewed by emotions, recent events or even peer pressure and media bullying. Therefore before making management decisions it is important to base everything on current data.

What does the recorded data tell us? Is this data relevant to the area? Are there other major factors influencing that data that have not be looked at? What time span is enough to get an accurate representation?

Structure versus function

Structure can loosely be described as the way the vegetation looks whilst function can be described as how it is used. Often decrease in structure may not influence the function at all. It must be asked if structure or function or both are necessary to achieve management objections and fall with in the TPC’s.

Importance of the issue and with this the willingness to make major changes

The importance of an issue refers to ranking of the issue in direct comparison to other issues. The question of where the situation fits into the ranking of importance gives an indication of resources needed to be allocated to that issue. Along with the importance comes the willingness of management to make changes according to the ranking decided. This willingness must match the importance of the issue to ensure that areas of concern are seen as priorities.

Future effects if nothing is done

The choice of leaving a situation and doing nothing can be a management decision in its own right. The importance of knowing what the consequences could be if nothing is done is often even more important than doing something. Monitoring of current situations, assessing previous trends and modelling future outcomes in important to gauge where the TPC will be crossed if at all.

Effects on other species

In a complexity of the trophic web all levels of organisms are linked and therefore their absence or presence can influence one or all other organisms. The influence can be both positive and negative and on a small or large scale. Research into or at least monitoring of the effects of one species on another can assist management to make decisions that will have the least potential disruption.
The scale at which things are done

Scale can play a role in both understanding the situation as well as finding options to manage the situation. Scale also plays an important role in the management actions needed and how these are implemented. Starting at a small scale the effect can be easily assessed, monitored and corrected but as scale increases so does complexity and the ability to control the effects. Scale refers to both the situation as well as the management actions.

The questions can be ranked in terms of importance from 1 (being the lowest) to 6 (being the highest) importance. These will then be put together with other results in a radar chart such as the one below.

<table>
<thead>
<tr>
<th>Weighted Questions</th>
<th>Land owner</th>
<th>Management</th>
<th>Ecological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale at which we want to do things</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Structure versus function</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Effects on other species</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Future effects if nothing is done</td>
<td>4</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Changes “perceived” versus changes “recorded”</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Importance of the issue and willingness to make major changes</td>
<td>6</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 2 Radar chart of priorities per management entity.
**Scenarios and actions**

The vegetation dynamics of the savanna ecosystem are driven by complex interactions between biotic and abiotic factors, and thus are expected to exhibit emergent properties of biocomplexity (Vanak et al 2012). Therefore there is no finite number of “how many elephants are too much”

Documents written for Sanparks after numerous Stakeholder meetings while working towards their management Policy in 2008 stated the following “The appropriateness of a particular management option is relative to the goals and context of a park” it continues to note that varies long term and short-term management goals must be taken into consideration with all decisions and “The most important aspects of context which influence the goals and thus methods of elephant management are:- Desired State of a specific park “ (Rogers et al 2008).This desired state must be agreed upon by all stakeholders and is very specific to the following factors

- Soils, vegetation, climate, regeneration strategies of woody plant species.
- Management history – culling, fire management, water supply.
- Size, shape, heterogeneity of protected area.
- Existence of rare and endemic vegetation types or species.
- Social, political and economic context.

Figure 3 highlights the possible options for elephant management in the SSW as well as the connectivity they have with each other and the multiple outcomes. Each Factor has both positive and negative effects and therefore using a diagram those effects can be tracked.

The following management options were compiled using both available literature and National Elephant Management Norms and Standards document. Each option is expanded in the following chapters.

The decision makers must take cognisance of the questions highlighted above when making decision regarding the management options available and must bear in mind the desired state that was agreed upon by all interested and affected parties. These decisions will lead the Sabi Sand Wildtuin into the future of elephant management.
Figure 3. A Mapping diagram highlighting the links around management options for elephant in the SSW, this is based on the issues affecting elephant management and policy diagram by Rogers et al 2008
Elephant Numbers and Vegetation Trends from data in the SSW

Data from the Aerial Census using a helicopter flying 500m transects at the end of the winter period (last week of August) starts in 1979, 1982 and 1990 through to 2012 (full method can be found in Peel and Stalmans, 2012 SSW Mala Mala joint Management Plan). Since the removal of the fence between SSW and KNP in 1993 Elephant numbers have dramatically increased from 60 to 1184 elephants in 2012, this is a density of 2.06 elephant/km². The KNP raised a concern when the density of elephant in KNP was 0.56 elephant/km² (Elephant symposium, Bakgatla, Pilanesberg National Park 2004). Therefore the high density of elephant in the SSW needs to be addresses. A noted period in Figure 4 below is 2002-2005 the density at this point was 1.46 elephant/km². Growth rates increases immensely when the fences were removed with the 3 year average in Figure 5 peaking in 1996 then declining till 2006. Over the 2002-2006 period the 3 year average growth rate is equal to or below the normal growth rate of 7% stated by Ian Whyte in 2004. He also stated birth rates increase 2 years after good rains which can be seen in the figure 4.

Figure 4 Elephant counts for the SSW from 1991-2012 aerial census including a polynomial trend line, layered over yearly rainfall, rainfall average and number of elephant removals.

Figure 5 Elephant population growth rate - yearly, 3 year average and 5 year average. The polynomial trend line is for the yearly rate.
The herbivore census data recorded for the same period shows mainly declines in population after the removal of the fence till 2003-2005 then the numbers show a marked increase. Figure 6 layers the herbivore numbers on rainfall, highlighting years of high winter rainfall.

![Figure 6 Aerial census figures from 1979-2012 for selected herbivores, layered on top of yearly rainfall indicating winter rainfall as well.](image)

To establish the effect of elephant on the vegetation data collected by the ARC was analysed by J van oort in 2013 (de Boer et al 2013 unpublished) to produce figures 7 to 11. Figure 7 shows a large decrease in tree density from 1993 to 2001, after which the density of trees stabilizes for all height classes.

![Figure 7 Tree density (Nx1000/ha) recorded in ARC sampling 1990 -2011 (de Boer et al 2013 unpublished unpublished)](image)
The number of stems per tree follows a similar trend in figure 8. After 2002 fluctuating around 2 stems per tree.

![Figure 8: Number of stems per tree over time from data collected by ARC 1990-2011 (de Boer et al 2013 unpublished unpublished)](image)

Elephant density follows an increasing linear trend from 1993 to 2004 at which point it is more erratic but seems to be plateauing out. This critical point is at the density of 1.5 elephants per km². This is reach in 2002 and 2004 indicated by the red arrows in Figure 9. When graphing elephant density against tree density in figure 10 there is a distinct cluster of points and tree density stabilises at 5 x 100 per square hectare from 1.5 all the way to 3 elephants per square kilometre. This baseline indicates a minimum effect level.

![Figure 9: Elephant Density (n/km²) in SSW over time (de Boer et al 2013 unpublished unpublished)](image)
Figure 10 Tree density from ARC sampling versus elephant density in SSW (de Boer et al 2013 unpublished)

Figure 11 The estimated total consumption of browse and grass of the relevant herbivores depicted as a percentage of the total consumption excluding elephants in Sabi Sand Wildtuin (de Boer et al 2013 unpublished)

The point at which consumption of browse and grass are at equilibrium is at densities between 1 and 1.5 elephants per square km as shown in figure 11 above. This consumption was derived by J van Oort (de Boer et al 2013 unpublished) based on animal counts and then extrapolated into percentage of browse versus percentage of grass consumed by the species.
Dominated by an increase in elephant densities the herbivore community structure has undergone changes in since 1992. A clear arch can be seen in the PCA (length of gradient <1) in figure 12, with the initial survey years in the lower right corner, continuing to the last years in the bottom left. The PCA was able to extract most of the variation in species composition on two axes only, accounting for in total 89% of the variation; the x-axis alone accounted for 71%. Elephant was strongly correlated with this first axis, which was also correlated by increases of all megagrazers: white rhino, buffalo and hippo. The nyala, a mixed feeder, also followed the elephant trend, but the other mixed feeder, the impala, was negatively correlated with changes in elephant population sizes as were giraffe, steenbok, and duiker, together with two grazer species, zebra and warthog. (de Boer et al 2013 unpublished)

The density of elephant from the Aerial census data 2004 – 2012 shows elephants counted over 8 years. The 95% density of those elephants (8553 of total 9053 counted) in figure 13 is distributed over only 40 % of the total area of the SSW. The highest densities are along major rivers and permanent water sources; this illustrates the reliance of elephants on water in the dry period. Studies done on collared elephants in the SSW by Bindi Thomas and John Holland (2011) concluded that elephant herds move further distances in the wet season and all herds experienced “closer distances to rivers and artificial water holes than would be expected if they were moving randomly”. The findings also revealed that the 3 herds showed major overlap in home range within the SSW but dispersed and should little or no overlap in the KNP. This can ask the question if elephant numbers is just a seasonal movement of animals from KNP into the SSW over a certain period. Thomas also highlighted “Core areas were centered on riverine habitats” and that home ranges did not fluctuate massively over the study period. (Thomas et al 2011) Do animals therefore move regularly into the SSW due to the available resources?
Figure 13 Density of elephants from 2004-2012 aerial census figures, the map shows 95% of the total elephants and also shows major rivers and water holes as black dots on the map.

Waterholes in the SSW provide water throughout the year and act as a sink for all animals from the KNP to move to the SSW during the dry periods. In 2006 J Swart did a water distribution assessment of the SSW (please see attached report). This report was based on data collected during the 2006 aerial census for all waterpoints including natural dams or pans, artificial dams on drainage lines, artificial and pumped pans. 868 pan and dams were recorded during the census, of which 543 (62.5%) were natural and 325 (37.4%) artificial. At the time 356 (41%) contained water. The annual rainfall average for 2005/2006 up to the date of the census was 1018, which is extremely high and can explain the reason for the high number of points with water. However Swart goes on to say “61.8% of the 233 artificial waterpoints were filled to the brim”, the aerial census is done at the end of winter and these points were still full so we can deduce that they are pumped and contain water year round. The 2006 data was then reduced to only “known” and named waterpoints as these would be permanent points if they have a name. Using this data, Figure 14 shows all water points that have permanent water, those that are full (regularly pumped) are highlighted in blue, a 5km and 10km buffer, created from the perennial Sand and Sabie Rivers was included to show the distances of water points from the natural river system. Of the 136 permanent water points only 12 fell outside the 10km buffer 124 were inside the 10km buffer and 81 of those were inside 5km.
Figure 14 Water point distribution in the SSW with a 5km and 10km buffer area from the river highlighted in blue. Permanent water points are highlighted in light blue with bigger circles.

The high density of water in turn brings high densities of elephants and the result is a high utilization of the vegetation. The position paper written by J Swart for the SSW in 2004, shows noticeable aesthetic differences in certain areas of the SSW with the change in vegetation structure. The independent scientific studies completed by Swart for the paper showed the following results.

- Overall severity of elephant impact on all tree height classes was 26%
- Overall severity of elephant impact on trees taller than 3m was 33.6%
- 51.3% of trees taller than 3m showed signs of impact of which 17.5% were killed
- 49% of the large trees (mainly knobthorn *Acacia nigrescens*) were killed by elephant in the knobthorn turf areas

Key to the research was the preference of species utilized by elephants as well as the area specific concentration predominantly on the turf soils. The fence line contrast allows for the comparison of two similar burning regime areas, with the same soil type and the determining difference for loss of trees is elephants. The significance of Fire and elephants together is highlighted by Enslin in 2000 showing that fire frequency has a major role in the recruitment of trees in the Savanna with frequent biannual
burns as well as frequent intense (late season) burns, young trees are restricted from escaping the fire trap (Enslin et al 2000). The utilization of saplings by herbivores can also contribute to the reduced recruitment of large trees in the SSW, when compared to the community all these factors need to be explored.

Although not a direct effect of elephants the combination of elephants and fire is one of major concern as together they reduce the tree density considerably (Trollope 2012) the KNP exclusion plots are a good example of how burning or elephants alone are not always major factors for tree decline but together they have the most impact. Shannon et al 2011 states “Elephant and fire are considered to be among the most important agents that can modify the African savanna ecosystem.” They went on to say elephants utilize previously burnt trees more and impact of subsequent fire was higher on previously burned or elephant utilized trees. “Responses of large trees were species and landscape-specific in terms of sensitivity to elephant and fire impacts” (Shannon et al 2011) again highlights the concentration of elephants to an area and the importance to manage those high utilization zones correctly. Figure 15 layers the percentage of burnt area in the SSW with annual rainfall and elephant numbers. The concern is the increase in elephant as well as the increase in burning in 2012 and the impact that may have on future tree recruitment.

Figure 15 Percentage of Burnt area of SSW versus the annual rainfall and elephant numbers.
Management Options

1. Do Nothing

The option to do nothing and monitor the situation as suggested by Van Aarde and Jackson in 2007 can be a decision in itself and can allow nature to continue in a flux, the precautionary measures that must be taken with this decision are, very close monitoring of both the system and all other species to ensure that the heterogeneity and biodiversity are not compromised. In a document written for Sanparks - History of KNP elephant population- Ian Whyte observed that the Recolonisation of elephants from Olifant's to Skukuza, a distance of 120km, took from 1909 to 1942. At the elephant symposium in Bakgatla 2005 when referring to the translocation efforts into the Trans frontier Park adjoining eastern KNP, Markus Hofmeyr confirmed that “family groups stayed for a while then returned possibly due to a disturbance”. However a recent presentation by the GLTP park warden at the PAMNF conference 2012 showed a higher number of elephant migrating from the KNP into the GLTP. SSW is part of a much bigger system and it may be only a matter of time to allow herds to disperse naturally. In 2005 Joubert suggested in his document - Some considerations regarding the management of KNP elephant population- If we would like numbers to self-regulate we need to create environment that puts pressure on the elephant. Therefore if we are going to do nothing to the population itself, we can manipulate the system to put get elephants to put pressure on each other.

2. Water points

It has been illustrated that the SSW has an exceptionally high number of water points. While water provision can be argued in the area as there is very little area in the SSW that is further than 10km from a perennial river, elephants need only drink every “1-2 days and are restricted to max movement range of 16km from water during the dry season” (Conybeare 1991). Why then is there over 25 scientific papers stating that the provision of artificial water is the biggest driver of elephant vegetation utilization?

Smit and Ferreira 2010 suggest “The spatio-temporal responses of elephants to distribution of resources and disturbances affect the intensity with which elephants use landscapes, which in turn affect their associated impacts on other conservation values”. Therefore plant species that are sensitive to elephant damage have a greater chance of survival in an area of less density. Removal of water from that area will decrease the density and therefore decrease the impact on the plant. Brits et al 2002 found “Shrub density increased with distance from the watering point, with the impact of large herbivores on shrub density extending up to 2.8 km”. This is not the only factor as the availability of water decreases the interaction and density around water points will increase.

Henley & Henley found a peak in the “number of musth bulls associating with breeding herds towards the end of the wet season”. With decreased water points the diminishing water will see an increase in musth bulls associating with breeding herds in close proximity to riparian zones, as herds often occupy the riparian areas. This would mean younger or non-musth bulls would avoid the conflict and will move to another area and thus relieve the pressure on the vegetation.

Therefore strategic closing of water points in areas with sensitive vegetation, high elephant density or a low number of large trees will help alleviate pressure on the vegetation.

3. Bees and Bio boundaries

The restriction of movements is usually been through the erection of fences and barriers, these fences or barriers prove inadequate or implausible to restrict the animal movements. Therefore the use of “Biologically relevant boundaries, or Bio-boundaries” (Jackson et al 2012) has been investigated as an alternative method of deterring wild animals from potential conflict causing areas. These artificial boundaries are created using biologically relevant signals that deter animals from moving into an area or crossing the “boundary”. There are a number of alternative forms of bio-boundaries that can be investigated, natural scent marking deterrents such as simulating intraspecific competition by artificial scent marking to create artificial territories. Or interspecific competition such as beehives and the danger they present to other animals in the immediate area. These so called “farm based deterrents” (King et al 2011) rely on negative experiences that swarms of bees have submitted elephants too and therefore the reluctance of being in an area that has indicators that there
is a bee hive in area. By simulating these indicators as recordings of angry bees, erection of old hives for smell and replication of the warning signals used by elephants when in distress we can deter animals from frequenting an area. These methods are purely experimental and are not guaranteed however they offer a more natural alternative to disturbance, with little limited visual pollution and may even provide for an opportunity to have a by-product such honey that can be made into a socio-economic project.

4. Translocation

Translocation has successfully been carried out in the SSW in previous years and although numbers of elephants removed were not high it may have had a role in disturbing the elephants in the area. There are a number of points to consider in translocation. Firstly it is important not to remove all the older bulls as the need for dominance in the hierarchy is most important. Family groups must all be removed together in a humane and acceptable manor. These family groups should not be split up so to reduce animals distress. Van Aarde 2006 makes note that translocation is “costly and cumbersome” and there is very little market for elephant as there are few conservation areas in Southern Africa that can accommodate more elephant. The opportunity to supply areas outside of southern Africa still exists but at a large expense. This option should still be explored as the increase in poaching for ivory is a concerning factor and translocation could be a possibility to save a dwindling population.

5. Habitat restriction

The restriction of elephants from a sensitive area through the use of fencing is an option that has been used successfully in other reserves such as Phinda Private Game Reserve and Addo National Park. The process is costly and has on-going maintenance cost but does serve a dual purpose of a research site to evaluate the effect of elephant alone over time. The fencing off using a 2 strand electrical wire is the most practical as it allows other herbivores (except giraffe) access to the area. There is however considerations that must be taken into account, firstly “fencing obstructs the movement patterns and migratory routes of large mammals” (Whyte and Joubert, 1988), and this causes bunching up against the fence and can therefore accentuate effects on vegetation and potentially homogenise impacts across the fenced-in landscape. Secondly the erection of a fence will restrict utilization within the fenced area but it will not decrease the numbers in the surrounding area and population will continue to increase. Another technique of fencing on a more intensive scale, to reduce debarking of tall trees, is the erection of chicken wire around trees. This method has been successfully used to protect nesting trees of vultures (S. Ronaldson pers. comm ). While this option is good on a fine scale it is not a good option on a large scale.

6. Contraception

The method of contraception has been tested and provides an option to control birth rates with hormones and their derivates, or with immuno-contraceptives (Pimm and van Aarde, 2001). The ethical debate regarding contraception is an issue that cannot be over looked. Current research by Audrey Delsink highlights the observations they have seen with the use of PZP. The report (http://www.hsi.org/assets/pdfs/elephant_immuno_report_2012.pdf) highlights a number of factors, Delsink states “To date, these trials have not demonstrated any aberrant or unusual behaviour within the medium-term and during sustained use of PZP on the experimental herds”. “There is also no evidence to suggest that the PZP vaccine has any adverse effects on the behaviour of matriarchal groups or bulls with important reproductive behaviours such as mate selection and bull dominance.”

The efficiency of PZP and the delivery method is more suited to smaller confined populations however the testing of a ‘one-inoculation’ vaccine is under way and should be available in 2014 this mould make it possible to do indiscriminate contraception in an open population. This method may prove costly due to the delivery method but the increase in calving intervals will decrease the growth rate of the population.
7. Culling

Culling is stipulated in the norms and standards and a final resort for population control, it is important that all other option are explored before as this is an emotive option. Culling will disrupt a population and can “cause immigration into the areas” (van Aarde 2007). The low densities in the culled areas, causes an influx of other elephants and therefore is not a permanent solution. Van Aarde 2007 reported that culling in 1995 in Hwange National Park saw an increase in elephant in 6 years of nearly double. Selective culling targeting bulls or animals of certain age classes also may distort age structures and enhance, rather than suppress growth rates (Gordon et al., 2004). The advantages of culling are the financial implications with both the option of hunting as well as mass culling and utilization of the products. The opportunity to create local community enterprise from culling is a factor to consider however it should not cloud the ecological judgement.

Precautions

All management actions should continuously be reviewed to take into account factors such as management decisions made by neighbouring reserves, wet and dry rainfall cycles including drought and finally climatic change and changing of seasonal patterns. The population of elephant is currently at its highest and due to the free movement of elephant to and from the Greater KNP consideration must be put in place for changes in behaviour of elephant due to pressures put on them in neighbours reserves and even farms. Artificial water point closures could potentially increase the elephant density in the SSW if it has not done already as seen in the increase populations graphs. This pressure will be exasperated in dry periods and could turn out to be detrimental in drought periods when pumped water points are the only source of water. Special considerations should put in place when considering management actions for water provisions, to ensure that a natural cycle of water is followed to elevate the drastic effects on vegetation surrounding water points in dry periods or droughts. Seasonal patterns in rainfall should be monitored and replicated to ensure natural balance is maintained in vegetation in areas of high artificial water point density.

Conclusion

This document serves to stimulate the discussion around the questions that must be asked when making an ecological decision. First and foremost an operational goal must be set by all stakeholders to ensure that all parties involved have a set desired state. The upper and lower limits of that desired state must be define and objectively ratified. Monitoring systems must be put in place and be scrutinised to ensure all possible linkages have been investigated and the biodiversity as a whole is not compromised. Lastly the management actions decided on must aim to achieve objectives, be answerable to investigation and be flexible to be re-evaluated and redirected should there be a need. The next step is to create a list of TPC’s for the Sabi Sand evaluate if monitoring of these systems is sufficient.

As a guide line the KNP TPC table for elephant is attached below.
Table 1: Thresholds of Potential Concom for Elephants in the Kruger National Park

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Measure</th>
<th>Within-zone TPC</th>
<th>Whole-park TPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation heterogeneity at coarse (range)</td>
<td>Coverage (by) of landscape scale units (e.g., semiarid to 30%)</td>
<td>80% change (cumulative) in the area of any landscape scale classification unit</td>
<td>30% change (cumulative) in the area of any landscape scale classification unit</td>
</tr>
<tr>
<td>Vegetation structure at community scale</td>
<td>Arranage, e.g., 4 site classes. Then homogeneity at 80% dominance of any 2 site classes.</td>
<td>80% of all plots homogenous. Sensitivity landscape assessed independently as well.</td>
<td>30% of all plots homogenous. Sensitivity landscape assessed independently as well.</td>
</tr>
<tr>
<td>Woody cover at community scale</td>
<td>Woody cover (within stratified landscapes, e.g., pasture) as determined from aerial photography, daisy-maps.</td>
<td>80% decline in canopy cover: specified increase with asynthes (see graph)</td>
<td>30% decline in canopy cover: specified increase with asynthes (see graph)</td>
</tr>
<tr>
<td>Ranks, sensitive or characteristic woody</td>
<td>None prepared to accept local loss or definite trend for a local loss of certain species unconnected to other species not declining seriously in 30% of the same area.</td>
<td>50% probability of population persistence for next 100 years</td>
<td>50% probability of population persistence for next 100 years</td>
</tr>
<tr>
<td>species for structural impact</td>
<td>Presence of aspera using seed heads, multifida, ill-horat, aspera, middle structure upper stratum.</td>
<td>Presence of perennials in area or border on current high elephant area.</td>
<td>Presence of perennials in area or border on current high elephant area.</td>
</tr>
</tbody>
</table>

Policy for the Management of the Elephant Population of the KNP

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Measure</th>
<th>Within-zone TPC</th>
<th>Whole-park TPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds as functional class</td>
<td>Presence of specific bird species as follows:</td>
<td>80% above</td>
<td>80% above</td>
</tr>
<tr>
<td>representation in open-pasture conditions</td>
<td>Phenacomya, emerya, monticola (both forest),</td>
<td>Phenacomya, emerya, monticola (both forest),</td>
<td>Phenacomya, emerya, monticola (both forest),</td>
</tr>
<tr>
<td>(what about adaptive species conditions?)</td>
<td>monticola (both forest), monticola (both forest)</td>
<td>monticola (both forest)</td>
<td>monticola (both forest)</td>
</tr>
<tr>
<td></td>
<td>Ground covers and water points are not</td>
<td>When any class disappears from any zone</td>
<td>Assumed to be natural</td>
</tr>
<tr>
<td></td>
<td>expected to be disturbed by elephants.</td>
<td>(see graph in whole-park TPC)</td>
<td>(see above)</td>
</tr>
<tr>
<td></td>
<td>Ground covers and water points are not</td>
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References


de Boer F, van Oort J, Grover M, Peel M. 2013 Elephant mediated plant community shifts shape herbivore species assemblages (under review)


