Ecological integrity

Plans for monitoring the Serengeti ecosystem and threats to the ecosystem

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Ephraim Mwangomo, Sue Stolton and Nigel Dudley

enhancing our HERITAGE

Plan for Monitoring the Serengeti Ecosystem and Threats to the Ecosystem

This document includes:

- ✓ **an overview of the development of the monitoring plan** (pages 2 - 5)
- ✓ **a summary and frequency of all monitoring activities** (page 6)
- ✓ **a more detailed analysis of the indicators being monitored** (pages 7 - 23)

Introduction to monitoring plan

In order to assess the outcomes of management of a site – i.e. whether management is actually protecting the unique values for which the site was designated – a monitoring programme is needed. The art of developing a good monitoring system is to select a few indicators that capture as much information as possible about different aspects of biodiversity and ecosystem functioning, without costing an unrealistic amount or taking too much time to monitor.

The plan being developed in the attached document is intended to monitor the ecological integrity or biodiversity health of the Serengeti Ecosystem. Ecological integrity is defined by Parks Canada as being "the state of ecosystem development that is characteristic for its geographic location, has a full range of native species and supporting processes and is viable, i.e. is likely to persist". We use this definition here.

Conservation Targets

The plan is based on monitoring eight Conservation Targets which have been selected to represent and encapsulate the unique biodiversity of the Serengeti Ecosystem. Indicators have been chosen to monitor both the Key Ecological Attributes (KEA) of the system and the most serious threats facing the system. This approach has been developed from The Nature Conservancy Enhanced 5-S framework – which is summarised below:

Identify focal biodiversity to be the focus of planning and represent all biodiversity

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Identify Key Ecological Attributes (KEAs) for focal biodiversity (factors that characterise and limit distribution including attributes of biological composition, spatial structure, biotic interactions, environmental regimes and connectivity plus size, condition and landscape context)

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Identify indicators for KEAs (that need to be maintained if biodiversity is to be conserved) – these should reflect target health, be recognised by stakeholders, reflect threats, provide early warning, and be cost effective and relatively easy to measure

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Rate the indicator status (for instance the natural range of variation to identify and distinguish anthropogenic variation)

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Integrate rating to determine status of key ecological attributes, specific elements of biodiversity, integrity of entire protected area of landscape

The KEAs and threat assessment for the Serengeti Ecosystem have been developed as part of the process to develop the new General Management Plan for the Serengeti National Park (GMPSNP) which will guide management activities from 2005 to 2015. The eight Conservation Targets are:

1. The Migration
2. The Mara River
3. Riverine Forest
4. Acacia Woodland
5. *Terminalia* Woodland
6. Kopje Habitat
7. Black Rhinos
8. Wild Dogs

It should be noted that the last two Conservation Targets (black rhinos and wild dogs) are ***restoration targets*** as black rhino numbers have dropped to only 40 animals in the Serengeti Ecosystem from a population of around a thousand in 1975, primarily due to poaching, and although wild dogs are present in the Serengeti ecosystem there are no longer any individuals in the Serengeti National Park.

Developing the Plan

The flow chart overleaf summarises the process undertaken to develop the indicators being monitored by this plan. The first step was undertaken as part of the GMPSNP process, the remaining steps have been developed by SENAPA Ecological Monitoring and the UNESCO Enhancing our Heritage project.

The Enhancing our Heritage project has drawn on global expertise to develop its framework for monitoring and assessing biodiversity (e.g. Parks Canada, Kruger National Park, The Nature Conservancy, the Wildlife Institute of India, WWF, University of Queensland). From this work some underlying principals for ensuring monitoring is effect, provides information for adaptive management and can be easily reported have been suggested.

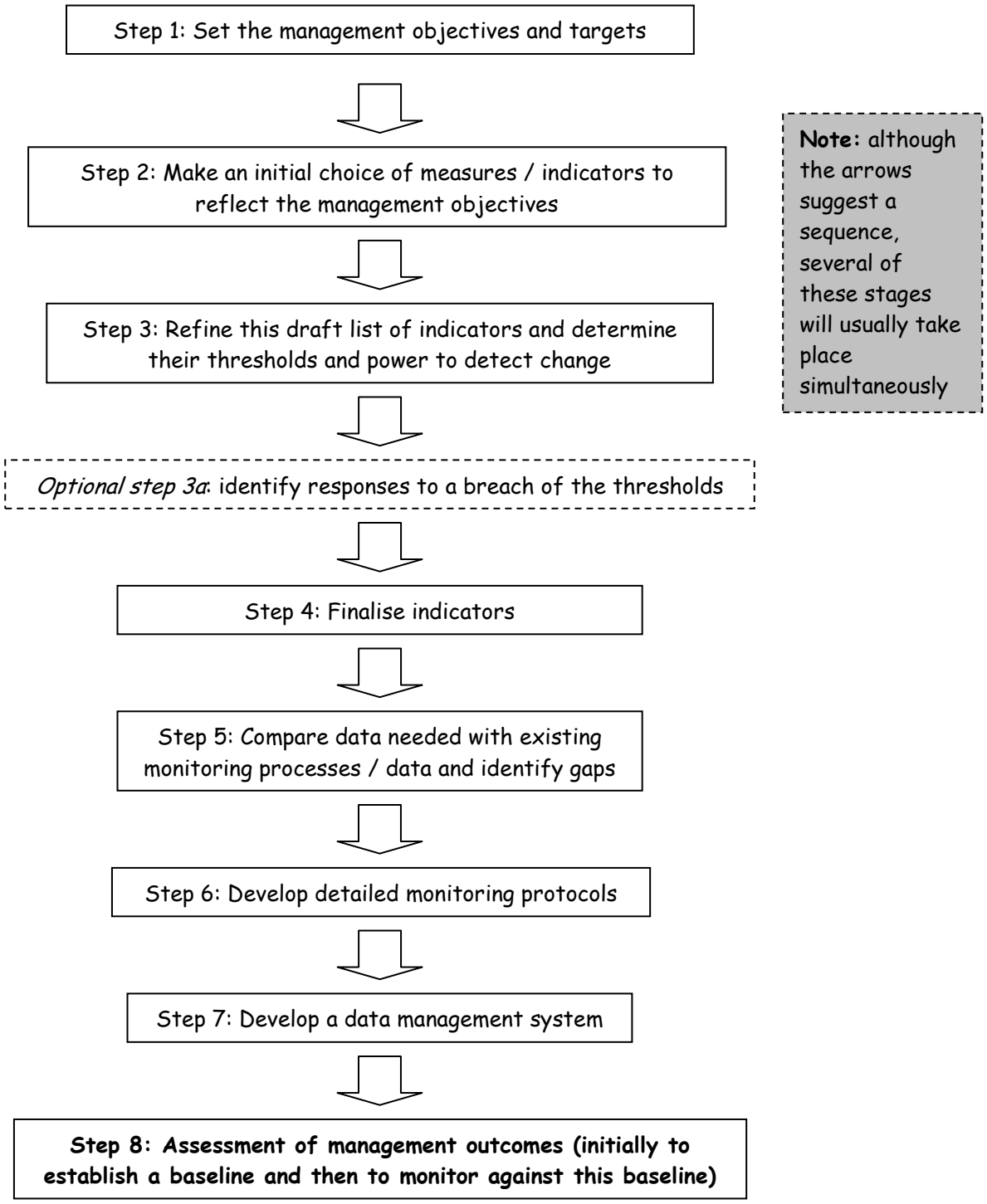
The core issues to be measured should included:

- Biodiversity: species richness, population dynamics and tropic structure
- Ecosystem functions: succession or retrogression, vegetation age-class distributions, productivity, decomposition and nutrient retention
- Stressors: human land-use patterns, habitat fragmentation, pollutants, climate and park specific issues

Three key challenges face those undertaking biodiversity monitoring:

- Unrealistic assumptions about data: in many cases, very little is known, but it is not realistic to monitor everything and fill all the data gaps
- Measuring the wrong things: the focus tends to be on large species, which are often very adaptable, and thus do not necessarily reflect other changes in the ecosystem
- Confusion of outputs and outcomes: many systems still make simplistic links between outputs (e.g. number of protected areas or management actions) and biodiversity health

Steps taken to develop a Monitoring Plan for the Serengeti Ecosystem



Indicators of status and threats

The following indicators have provisionally been agreed to monitor status and threats in Serengeti

Status indicators

Conservation target 1: The migration	✓ Traditional migratory routes ✓ Population size of key species ✓ Productivity / recruitment ✓ Forage quality/spatial availability
Conservation Target 2: The Mara River	✓ Water flow rate ✓ Water quality ✓ Forest habitats
Conservation target 3: Riverine forest	✓ Forest area and cover ✓ Indicator species
Conservation target 4: Acacia woodland	✓ Density of key tree species ✓ Herbivores in woodlands
Conservation target 5: *Terminalia* forests	✓ Density of *Terminalia* ✓ Herbivores in woodlands
Conservation target 6: Kopje habitat	✓ Main kopje plant species ✓ Main animal species
Conservation target 7: Black rhino	✓ Suitable habitat ✓ Population ✓ Productivity
Conservation target 8: wild dog	✓ Population ✓ Productivity

Threats indicators

Conservation target 1: The migration	✓ Decline in Mara River flow rate ✓ Poaching ✓ Cutting of migration routes ✓ Early dry season fires ✓ Cultivation (Masawa, Lake Victoria) ✓ Disease ✓ Fencing (creating hard boundary) ✓ Bore holes (NCA)
Conservation target 2: The Mara River	✓ Pollution ✓ Bank erosion
Conservation target 3: Riverine forest	✓ Fire
Conservation target 4: Acacia woodland	✓ Fire
Conservation target 5: *Terminalia* woodland	✓ Fire
Conservation target 6: Kopje habitat	✓ Fire
Conservation target 7: Black rhino	✓ Poaching ✓ Unviable population size ✓ In-breeding ✓ Human disturbance ✓ Availability of secure habitats
Conservation target 8: Wild dog	✓ Unviable population size ✓ Inbreeding ✓ Human-wild dogs conflict

Summary and frequency of monitoring activities

The agreed monitoring activities are summarised below in order of the frequency with which they need to be undertaken

Activity	Indicator Monitored	Frequency
1. Satellite and ground survey?	▪ Fire patterns and extent of dry season fires	Fire management plan ?
2. Blood and tissue sampling	▪ Mortality of key species	Opportunistic
3. Questioning apprehended poachers	▪ Continuing increase in poaching ▪ Increase in poaching mortality (Black Rhino)	Opportunistic
4. Water pressure, temperature	▪ Minimum flow rates ▪ Water Quality (Mara River)	Automatically every 30 minutes
5. Field recording	▪ Population size (Black Rhino) ▪ Rhino sex ratio and proportion of young	Daily
6. Ranger observations	▪ Number of visitors in the Rhino Conservation area	Daily when migration in areas
7. Data collection	▪ Rainfall patterns and trends	Daily and monthly
8. Flow rate, dissolved oxygen, pH, salinity, visibility	▪ Water quality (Mara River)	Monthly
9. Census data, village records and satellite data	▪ Continuing population pressure and extent of cultivation near migratory routes	Annually
10. Boundary survey	▪ Intact park boundary	Annually
11. Ground surveys	▪ Number of bore holes in NCA	Annually?
12. Aerial surveys	▪ Seasonal migratory movements ▪ Population size of large ungulates ▪ Resident ungulate species (in Acacia and *Terminalia* woodland)	Two years
13. Transects	▪ Recruitment of key species (ratio of juveniles to adults)	Two years
14. Ground counts/ transects	▪ Oribi density (in *Terminalia* woodland)	Three years
15. Ground counts/ transects	▪ Population size of key carnivores (except lions)	Five years
16. Photo IDs and call back	▪ Population size of lions	Five years
17. Trail plots	▪ Forest extent/size and cover (and width of Mara River)	Five years
18. Vegetation surveys	▪ Monitor selected sites (Kopje Habitat)	Five years
19. ?	▪ Wild dog numbers ▪ Wild dog recruitment ▪ Incidence of human - wild dog conflict	To be determined

A monitoring plan

In the following set of tables, the indicators are discussed in detail. Information is given on a ten different issues:

1. **Indicator**: a simple description of the indicator

2. **Target**: which one of the eight targets the indicator relates to

3. **Value being measured**: either the key ecological attribute in the case of indicators of status or a threat to attaining the target in the case of indicators of pressure

   - ✓ **Key ecological attribute**: structure, composition, interactions and abiotic and biotic processes that enable the target to persist through their influence on the target's size, condition and landscape context
   - ✓ **Threats**: the identified threat to the target

4. **Justification for selection**: reasons why a particular indicator has been chosen

5. **Minimum integrity thresholds**: the level at which the indicator gives cause for concern. This can sometimes have both an upper or lower limit (e.g. the minimum and maximum sizes that an animal species can reach before it causes serious concerns). In time and with more research such thresholds should have numerical values; at the moment most for Serengeti are based on trends.

6. **Confidence level of threshold**: an indication of how much confidence we have that the threshold is accurate

7. **Monitoring activity**: what needs to take place to collect information about the indicator

8. **Monitoring details** (status, protocols, responsibilities): how information should be collected (methodology, timing, who is responsible etc), the status of information collection at the moment etc. This is an important section, which should give enough information so that if staff change the way in which data are collected remains the same and therefore indicators are comparable over time. More details on developing monitoring protocols are given overleaf.

9. **Cost and funding sources**: details of how much monitoring costs and where the funding comes from; this should also give some details about the security of funding

10. **Management options**: what to do if the threshold is breached; i.e. a set of predetermined management responses so that action can be taken quickly there is a problem.

Monitoring protocols

Monitoring protocols help ensure quality and credibility, so that monitoring is carried out consistently, data are suitable for comparative analysis, and any changes detected are real and not due to differences in sampling, for instance if staff change. Monitoring protocols should be reviewed and tested, and provision for review and revision built into the protocol.

Some suggestions as to the sort of information which can be included in protocols are given below:

Protocol Design

- **Method**: Method or methods used (e.g. sampling, interviews, observation, line transect techniques, traps or strip census methodology)
- **Procedures**: Standardised procedures for collecting data, including, area of monitoring, staffing requirements (e.g. numbers, required training, time allocated), equipment requirements (e.g. vehicles, binoculars, GIS, traps) and safety procedures
- **Frequency of data collection**: i.e. monthly, quarterly, annually etc
- **Data collection**: Indicators to be measured (e.g. species, numbers of sightings, fire frequency, average earnings of local communities)
- **Data analysis**: advice regarding analysis and comparison (e.g. use of graphs, analysis software, comparisons etc)
- **Data management**: Records should include not only the monitoring results (data sets) but also the history of monitoring development and revision

Protocal Adaptation

- **Review**: As with all management activities undertaken in a World Heritage site, monitoring activities should be regularly reviewed to ensure that not only are the right things being monitored, but that this monitoring is being carried out in the most effective way
- **Revision**: Although protocols aim to ensure standardisation of monitoring (for the reasons discussed above) protocols should also adapted and revised if the review process indicates this need. Revision may need to take place due to changes in technology, gaps in data need, budget changes, changing conditions on the ground including new pressures, etc.

Additional information on monitoring protocols:

- **Guidelines for long-term monitoring protocols**, printed in the *Wildlife Society Bulletin* 2003 31(4) 1000-1003. See: science.nature.nps.gov/im/monitor/protocols/ProtocolGuidelines.pdf
- Environment Canada's Ecological Monitoring and Assessment Network protocols on: **Biodiversity Monitoring; Ecosystem Monitoring and Community-based Monitoring**. See: www.eman-rese.ca/eman/
- US National Parks Service Inventory and Monitoring Program (science.nature.nps.gov/im/monitor/index.htm)

Indicator: Seasonal migratory movements (in the west of the Grumeti River (Ikona WMA); East Kuka/West Loliondo route to Kenya; Salai Plains, Lake Victoria; Maswa, Grumeti and Ikorongo GR)
Target: The Migration **Key Ecological Attributes:** Traditional migratory routes
Justification for selection: Threats to the ecosystem which support the migration route, especially in the areas outlined above

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options/implications
If there is a breakdown of traditional migratory routes	High	**Current:** Ranger reports daily and anti-poaching patrol that follows migration	Need system to systemise and analyse information into GIS system	SNP, FZS	Increasing the protection status for areas covered by the migration outside of the Park.
		Current: Wildebeest Collars (suggest that this is probably not a cost-effective method of monitoring migratory routes)	Information from eight collars has been collected over the last # years but seven collars are no longer in operation. For this type of monitoring to be effective some 40 collars would need to be operating.	US$4,000 per collar	
		New: Mapping migratory routes through aerial point survey	Monthly surveys during times when migration is outside Park boundary	SNP, FZS, TAWIRI (affordable and staff have skills needed)	

Indicator: Population size of large ungulates
Target: The Migration **Key Ecological Attributes:** Population size of key species
Justification for selection: To monitor the long-term trend in populations and the causes of fluctuations (e.g. poaching and disease) that are not expected from natural processes such as drought. Results of monitoring are also used by the Wildlife Division to grant hunting permits (see also indicator on recruitment)

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Major unnatural fluctuation	High	**Current:** Aerial surveys and photographs	• Surveys every two years of migration • Carried out by TAWIRI - CIMU (SNP, WD, NCAA, FZS)	TANAPA/NCA/WD and FZS own the aircraft. TANAPA provide staff. FZS provide fuel and allowances for staff.	Check census data for species under concern. Look for causes (i.e. disease/poaching) and any remedial actions. Decline in any species that raises concern can trigger follow up survey in following year to verify trends.

Indicator: Population size of key carnivores except lions
Target: The Migration **Key Ecological Attributes:** Population size of key species
Justification for selection: Healthy populations of carnivores reflect a healthy migratory system.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Major unexplained fluctuations	High	**Current:** Ground transects (open plains only) **Current:** Visitor sighting reports for cheetah	• Every five years carried out by Tanzania Carnivore Centre • Continuing – now web-based system	Tanzania Carnivore Centre Tanzania Carnivore Centre	First check data and then look for sources of change – probably disease

Indicator: Population size of lions
Target: The Migration **Key Ecological Attributes:** Population size of key species
Justification for selection: Healthy populations of carnivores reflect a healthy migratory system.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Major fluctuations in populations	High	**Current:** Long term lion research (i.e. photo IDs on the plains, call back etc) – focussed on Seronera and Eastern Plain for logistic reasons	• Long term research carried since the 1960/70s. • Five year counts	Funded Lion Project of the Tanzania Carnivore Centre	• Check data • Find the cause • Determine responses, i.e. vaccination programmes in the case of disease

Indicator: Recruitment of key species
Target: The Migration **Key Ecological Attributes:** Productivity
Justification for selection: Provides information on population trends

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Declining juveniles	High	**Current:** Sampling transects to assess ratio of juveniles to females (or adults if sex differentiation is difficult)	• Every two years • Sampling transects	Currently being carried out by the Serengeti Biodiversity Project (Tony Sinclair)	• Check data • Find the cause • Determine responses (disease a likely cause)
		New:	Need to review SBP monitoring program and determine minimum program requirements and costs for TANAPA to take this on.	SENAPA Ecological Monitoring to take over the monitoring	

Indicator: Disease and mortality of key species
Target: The Migration **Key Ecological Attributes:** Productivity
Target: The Migration **Key Ecological Attributes:** Disease
Justification for selection:

Minimum integrity thresholds	**Confidence level of threshold**	**Monitoring activity**	**Monitoring details (status, protocols, responsibilities etc)**	**Cost and funding source**	**Management options**
Unexplained mortality Incidence of disease Rinderpest, anthrax – (ungulates) Canine distemper (carnivores)	High	**Current:** Sampling blood and tissue from dead animals **Current:** disease surveillance	• Opportunistic sampling to determine cause • Monthly	TANAPA Vet. Dept & Ecological Monitoring SENAPA VO	Depends on nature of disease

Indicator: Rainfall patterns and trends
Target: The Migration **Key Ecological Attributes:** Forage quality and spatial availability
Justification for selection: Integrity of the ecosystem

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Increased frequency and severity of droughts	Medium	**Current:** Rainfall data recorded in research monitoring reports (54 stations, currently investigating automatic stations (5 may be funded by research project)	• Daily and monthly data from rainfall gauges and GIS • Possible linking daily rainfall pattern with migration patterns • Database to manage rainfall data is being developed	TANAPA/ SENAPA/ FZS	?
		New: Reviewing abandoned gauges to increase coverage	Could analyse detailed data from K. Campbell to determine the optional number and location of rainfall guages	?	

Indicator: Fire patterns and extent of dry season fires
Target: The Migration **Key Ecological Attributes:** Forage quality and spatial availability **Threats:** Early dry season fires
Target: Riverine Forest **Threats:** Extent, frequency and heat of fire
Target: Acacia Forest **Threats:** Extent, frequency and heat of fire
Target: *Terminalia* Forest **Threats:** Extent, frequency and heat of fire
Target: Kopje Habitat **Threats:** Extent, frequency and heat of fire
Target: Black Rhino **Key Ecological Attributes:** Habitat suitable for Rhinos **Threats:** Habitat lost due to fire
Justification for selection: Human induced fires (started by poachers) are a major threat to forests (i.e. *Terminalia*) and plants (i.e. Xerophytic on the Kopjes) that are not fire adapted. Activities need to be focussed towards prioritised areas (to include Montane systems in the Mara and Congo forest systems in Grumeti/Mbalageti) which are being identified in the fire management plan. It is suspected that cycles of woodland and grassland take place over around 90 years

Minimum integrity thresholds	**Confidence level of threshold**	**Monitoring activity**	**Monitoring details (status, protocols, responsibilities etc)**	**Cost and funding source**	**Management options**
Any fires in fire refuge area	High	**Current:** Satellite and ground survey to assess frequency of fires and scarring	See fire management plan		See fire management plan
		New: ?	See fire management plan		

Indicator: Continuing increase in poaching
Target: The Migration **Threat:** Poaching
Justification for selection:

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Trend in poaching off-take	High	**Current:** Questioning apprehended poachers, for details of numbers of animals taken, success rates of snares, etc	• Questionnaires opportunistic • Need to develop measure of poaching detections per unit of patrol effort	SENAPA Protection Department	Increase effectiveness of capturing poachers including extending rewards to park rangers for snares retrieved. Use of village courts as a stronger deterrent for poaching.
		Current: Number and locations of poaching camps and incidents	• Will be included in GIS in future • Need to also collect data on anti-poaching patrol effort	SENAPA Protection Department	

Indicator: Continuing population pressure and extent of cultivation near migratory routes
Target: The Migration **Threat:** Migration routes
Justification for selection: The expansion in population and areas under cultivation in the western part of the Serengeti ecosystem

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
If human population pressure has major impacts on ecosystem integrity	High	**Current:**			
		New: Annual assessment of census data, village records and satellite data to determine trends in: • human population • cattle • cultivation	• Population and livestock data from Bureau of Statistics and village records and photo points is collected by SENAPA (Outreach), • Satellite data (Aster) for assessing agricultural encroachment • Check source of FAO data on cattle numbers	NASA – initial assessment organised through NASA-UNESCO agreement Funding needs to be assessed (staff time and photos/ satellite pictures)	Advocacy - politicians

Indicator: Intact park boundary
Target: The Migration **Threat:** Blocking migration routes
Justification for selection: Ensure that park boundary beacons are intact to stop encroachment into the park

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
If there was major damage to park boundary beacons	High	**Current:** Boundary survey to monitor integrity of park boundaries	Annual monitoring existing park boundaries (which are marked by beacons every 500m) by the SENAPA Protection Warden Coverage of park boundary incomplete – being progressively extended	SENAPA Protection Department	Ensure the park boundary is well marked (Government Land Use Surveyors are currently completing the demarcation of the boundaries) and that the boundaries continue to be intact

Indicator: Agricultural area in the NCA (The original indicator discussed at Ecosystem Management workshop was number of bore holes, but it was felt that the increase in agricultural areas was a better indicator of threat for activities in the NCA)
Target: The Migration **Threat:** Settled agriculture in the NCA
Justification for selection: Bore holes create permanent water sources, which can stop the migration.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Increasing trends in farm creation	High	**Current:** Ground surveys to assess occurrence of farms in NCA	• Satellite monitoring (in association with assessing cultivation expansion on western boundary of SNP) • Ground survey by NCA • SENEPA Ecological Monitoring tracking the situation	NCA NASA	Liaison with NCA officials

Indicator: Water Quality
Target: Mara River **Key Ecological Attributes**: Water Quality **Threat:** Pollution
Justification for selection: Long-term monitoring to see if there is a change in the catchment (i.e. pollution) which would impact animal use of the water.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Trend in increasing pollution	High	**Current:** Dissolved oxygen, pH, salinity, visibility, temperature	Data collected monthly near Kogatende Bridge (Data analysis being assisted by Eric Wolanski)	SENAPA Ecological Monitoring	Advocacy

Indicator: Minimum flow rates
Targets: Mara River **Key Ecological Attributes**: Water flow **Threat:** Water diversion and extraction
Justification for selection: The Mara River provides critical water supplies for wildebeest during drought. Data suggests that flows have been declining.

Minimum integrity thresholds	**Confidence level of threshold**	**Monitoring activity**	**Monitoring details (status, protocols, responsibilities etc)**	**Cost and funding source**	**Management options**
Continual decline in flow rates	High	**Current:** Measurement of water pressure and temperature, to extrapolate flow rate	Pressure and temperature recorded Kogatende Bridge collected every 30 mins, and flow rates physically recorded monthly. From this you can extrapolate trends in flow rate. (Data analysis being assisted by Eric Wolanski)	SENAPA Ecological Monitoring	Policy interventions to ensure the flow rate is not compromised by activities outside the park (such as hydro-electric developments in Kenya)

Indicator: Forest extent/size and cover (and width of Mara River)
Targets: Mara River **Key Ecological Attributes**: Forest habitats (inside SNP)
Targets: Riverine forest **Key Ecological Attributes**: Forest extent and size
Targets: Acacia Woodland **Key Ecological Attributes**: Forest extent and size
Targets: *Terminalia* Woodland **Key Ecological Attributes**: Forest extent and size
Targets: Black Rhino **Key Ecological Attributes:** Suitable woodland habitat (in the north – *Terminalia*, riverine thickets, hill thickets; in the west – *Sensievaria*, *Salvadora* spp etc)
Justification for selection: Concerns that forest cover is changing beyond the expected natural cycle. (This monitoring will also include any indication of bank erosion, which can be subject to further monitoring if this is seen as necessary)

Minimum integrity thresholds	**Confidence level of threshold**	**Monitoring activity**	**Monitoring details (status, protocols, responsibilities etc)**	**Cost and funding source**	**Management options**
Forest changes at an unnatural rate and/or extent	High	**Current:** Trial plots to assess forest change	• Photo points to be monitored very five years (during wet and dry season) • Markers to be placed to provide a reference point for change (Aim to do this with Tony Sinclair when he next visits in November)	Currently carried out by the Serengeti Biodiversity Project, to be taken over by Serengeti Ecological Monitoring	More information is needed before management options can be determined
		New: Vegetation patterns and changes and changes in Mara River banks	• Satellite, GIS and vegetation mapping	SENAPA Ecological Monitoring and FZS to explore feasibility of satellite monitoring with NASA/UNESCO	

Indicator: Resident ungulate species
Targets: Acacia Woodland **Key Ecological Attributes**: Herbivores of woodland
Targets: *Terminalia* Woodland **Key Ecological Attributes**: Herbivores of woodland
Justification for selection: The unique wildlife in the woodlands one of the key features of the Serengeti

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Trend in decline	High	**Current:** Aerial census data (including photographs). Total counts by blocks	Every 2 years ▪ Total count of buffalo and elephants All large mammal	TANAPA/NCA/WD and FZS own the aircraft. TANAPA provide staff. FZS provide fuel and allowances for staff.	Need to set criteria for response to a certain level of change in population (to be carried out after study tour to Kruger NP)

Indicator: Oribi density
Targets: *Terminalia* Woodland **Key Ecological Attributes**: Herbivores of woodland
Justification for selection: This species is only found in these woodlands.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Trend in decline	High	**Current:** Ground counts by transect	▪ Ground counts every three years	Simon Mduma of Serengeti Biodiversity Project – specialised project	Need to set criteria for response to a certain level of change in population (to be carried out after study tour to Kruger NP)

Indicator: Monitor selected sites
Targets: Kopje habitat **Key Ecological Attributes**: Main kopje plant species
Targets: Kopje habitat **Key Ecological Attributes**: Main kopje mammal species
Justification for selection: Kopje unique habitat in the park

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring details (status, protocols, responsibilities etc)	Cost and funding source	Management options
Major change in species composition	High	**Current:** Vegetation surveys	Permanent sampling using photo points, quadrates and transacts every five years	SENAPA Ecological Monitoring	Protect Kopje from wildfire
Density of Klipspringer and 2 Hyrax species	Medium	**New:** Animal census reports	Census every 5 years	SENAPA Ecological Monitoring	Protect Kopje from wildfire

Indicator: Population size
Targets: Black Rhino **Key Ecological Attributes:** Rhino numbers
Justification for selection: Black Rhino numbers have significantly declined over the past 30 years due to poaching, leading to concerns about viability of population size. There are discussions about reintroducing Rhino in some areas

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Decline in population	High	**Current:** All rhino's left in the park are subject to full time monitoring	Routine daily monitoring	Rhino Project Unit, TANAPA Dept of Protection and Ecology	TANAPA Rhino Project Unit, Dept of Protection and Ecology created for full time monitoring and protect rhino populations

Indicator: Rhino sex ratio and proportion of young
Targets: Black Rhino **Key Ecological Attributes:** Productivity (recruitment)

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Decline in population	High	**Current:** All rhino's left in the park are subject to full time monitoring	Routine daily monitoring	TANAPA Rhino Project Unit, Dept of Protection and Ecology	TANAPA Rhino Project Unit, Dept of Protection and Ecology created for full time monitoring and protect rhino populations

Indicator: Increase in poaching mortality
Targets: Black Rhino **Threat:** Poaching
Justification for selection: Numbers have declined through poaching.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Decline in population	High	**Current:** Mortality	Anti-poaching controls, capturing poachers etc	SENAPA Protection Department	Increase effectiveness of capturing poachers including rewards to park rangers for poachers captured. Use of village courts as a stronger deterrent for poaching. Amnesty for guns held without permits.

Indicator: Number of visitors in the Rhino Conservation area
Targets: Black Rhino **Threat:** Human disturbance

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Evidence that visitor numbers are disturbing rhino	?	**New:** Ranger observations to monitor number of vehicles in the Rhino Conservation area **New:** Analysis of stress hormones in rhino dung	Ranger observation posts tracking cars and any off road activity Need to develop vehicle tracking form for data recording Cost needs to be assessed – and if Rhino Project can meet this cost	SENAPA rangers and Ecological Monitoring Rhino project	Controlling visitor access, ensuring no off-road driving and close any unofficial tracks

Indicator: Wild dog numbers
Targets: Wild dogs **Key Ecological Attributes:** Population size
Justification for selection: There are currently no wild dogs in the Park and numbers are under threat in the ecosystem. Monitoring will take place when wild dogs are either introduced.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Decline in wild dog numbers	High	**New:** Total count	Photo ID	SENAPA Ecological Monitoring	Re-introduction

Indicator: Wild dog recruitment
Targets: Wild dogs **Key Ecological Attributes:** Productivity (recruitment)
Justification for selection: There are currently no wild dogs in the Park and numbers are under threat in the ecosystem. Monitoring will take place when wild dogs are either introduced.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Decline in wild dog numbers	High	**New:** Total count of juveniles to females (for adults)	Photo ID	SENAPA Ecological Monitoring	Re-introduction

Indicator: Incidence of human - wild dog conflict
Targets: Wild dogs **Threat** Human-wild dog conflict
Justification for selection: Monitoring will take place when wild dogs are either introduced.

Minimum integrity thresholds	Confidence level of threshold	Monitoring activity	Monitoring protocol (including frequency of measurement and person/s responsible)	Cost and funding source	Management options
Increase in conflict levels	High	**New:** Shooting/poisoning incidences and conflict	Opportunistic	SENAPA Ecological Monitoring	More information is needed before management options can be determined