Ecological implications of food and predation risk for herbivores in the Serengeti

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Chapter 9

Ensuring the long-term conservation of ecosystems: The role of cataloguing and disseminating information.

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Abstract

National parks and reserves are under increasing pressure from human disturbances, which raises the question of how to ensure their long-term protection for future generations. From the experience gained in North Luangwa (Zambia), Gonarezhou (Zimbabwe), and Serengeti (Tanzania) we see that successful conservation projects are ones that aim to catalogue and disseminate information about the protected area. Monitoring programs are critical to long-term conservation because they (a) provide institutional memory, which (b) enables parks to critically investigate processes and answer management questions independently. Furthermore, routine collection of information about a protected area (c) highlights priorities and facilitates the wise use of financial resources. In addition, information collected by parks (d) contributes to understanding regional processes and (e) ultimately supports conservation efforts in the political arena by providing a factual backbone on which assertions and decisions are made. Ideally, a monitoring program for a protected area should reflect the objectives established in the General Management Plan (which also documents the threats the protected area faces). We provide examples from projects sponsored by the Frankfurt Zoological Society to illustrate how to balance the costs and effort involved in collecting data against its relevance. Using examples from several African conservation programs we show how current ecological questions relating to illegal activity and rhino reintroductions can be understood by accessing historical data especially in the form of vintage photos and reports. By far the most effective way to collect new information about a national park and to mitigate future risks is via a ranger based monitoring program. An example from North Luangwa illustrates how a ranger based monitoring system combined with GIS has been exceptionally useful for protected area management. We provide several good sources of information that would be immediately useful for national park management, and discuss ideas as to how to collect, store, and disseminate data for protected areas with limited infrastructure. From our experiences, monitoring system only work when they start very simply and develop with the park, growing to fill the niche as it is required.

Why monitor? (5 good reasons)

What are the benefits are gained by monitoring, especially when collecting information can be long and tedious at times? The collection of data, especially over a long time, gives a park what's called **institutional memory**. In other words, it provides a source of knowledge that will long out-last any of the rangers, mangers, or researchers. Many ecological processes occur on scales that are well beyond our lifetime (Arcese & Sinclair, 1997; Sinclair, Ludwig & Clark, 2000; Sinclair *et al.*, 2007) and cataloguing the state of an ecosystem over long periods of time enables us to understand these dynamics. A database allows us to recall these occurrences and learn from these events, even though we personally may never have experienced them. Therefore, we are building on our knowledge over time, rather than forcing each generation to re-learn it (Swetnam, Allen & Betancourt, 1999).

Managers in national parks are constantly presented with choices. For instance, managers in African national parks face questions such as; where should we place tourist roads? Which villages should receive financial support this year? Are we catching poachers efficiently? Experience allows managers to make good choices, but often a manager is forced to make a decision on something with which they have little or no experience. In other words, they are forced to guess, and in some cases they have the luxury of making an educated guess (Walters, 1986). For park management, there are no clear answers for most questions, however we can learn from our previous choices provided we have documented them. For instance, using anti-poaching data from the Serengeti that has been collected for 40 years, a recent analysis (Hilborn *et al.*, 2006) shows that increasing the national park budget for resource protection resulted in more poachers being caught and a recovery of buffalo, elephant and rhino populations (Figure 1). This tells us about the efficiency of anti-poaching patrols and provides useful information as to where to concentrate resources. Having access to information means we can **answer important management questions** with greater confidence.

Unfortunately, the funds for national parks are limited. There is rarely enough money to do everything, so we are forced to prioritize our activities. In general, we prioritize activities based on threats and benefits they pose, or how critical they are to conservation. By collecting information about the park, we can more easily **prioritize activities and use limited financial resources most wisely**. For example, plans to re-introduce black rhino into the Serengeti Ecosystem raised the question as to where to release them. Ideally a rhino reintroduction program aims to maximize the chances of successfully establishing a breeding population while minimizing the risk of having animals poached. Researchers were able to answer this question by using historic data sets without having to waste resources on a trial and error approach. Analyzing the historic rhino distributions from the 1970's researchers created a habitat suitability model. Current data on poaching pressure was mapped for the entire ecosystem and

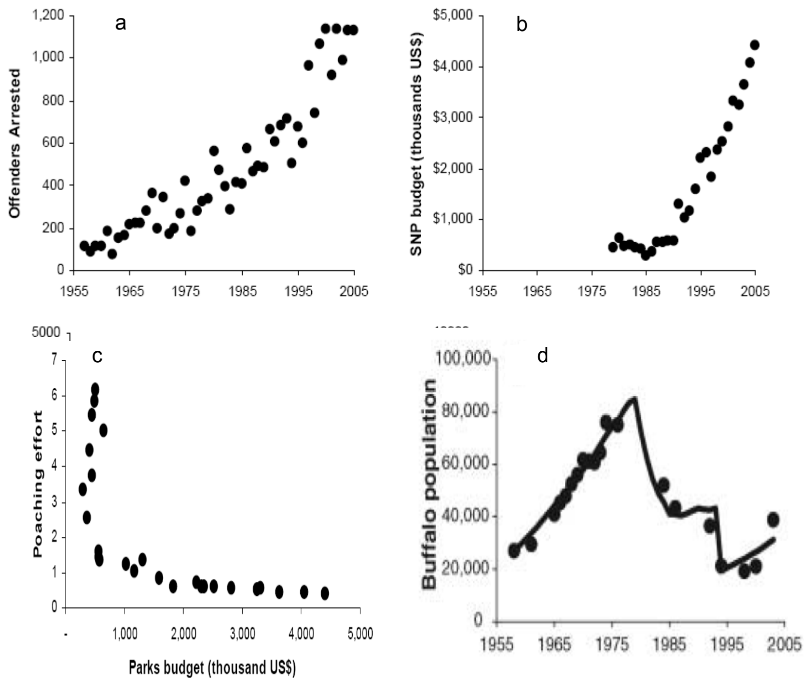


Figure 1. An analysis of historic data from Serengeti shows that (a) the number of poachers arrested increases if (b) the budget for resource protection is increased. Furthermore, (c) as resource protection budgets increase the number of days poachers spend in the park (i.e. poaching effort) decreases which results in (d) the recovery of wildlife such as buffalo (only after 1995 did national parks invest sufficient money to reverse the loss of buffalo due to poaching). This illustrates the importance cataloging information because it allows a national park to answer the management questions that are specific to their needs (data from (Hilborn *et al.*, 2006)).

overlaid with the habitat suitability model, enabling researchers to pin-point potential reintroduction areas that were both safe and good rhino habitat (Metzger *et al.*, 2007) (Figure 2 and 3). By collecting information we are able to prioritize park activities better which means using limited financial resources with greater efficiency.

Globally our protected areas are coming under increasing pressure. Although we are busy exploring the outer limits of our solar system, the irony is that we barely know what's happening on our own planet. We know as much about our ecosystems as a 6 year old would know about an engine of a vehicle: we know that the brakes slow us down, the accelerator speed us up, that driving too fast is little scary, and when we hit potholes it goes bump. But we know precious little about internal combustion, torque, gears, and crankshafts. We like to think of protected areas as beautiful places where we can see wildlife and get away from the hustle and bustle, but more practically, national parks serve as baselines from which we can measure our ecological footprint. The collection of information from national parks shows us what is happening in areas of our world where we have little impact (Arcese *et al.*, 1997; Sinclair *et al.*, 2000; Sinclair, Mduma & Arcese, 2002). More to the point, they show us what we are doing to the rest of the world and how things would look in our absence. Furthermore, by **combining knowledge** from many different ecosystems we start understanding how our how planet's engine works.

Conservation is politics. It's a bitter pill for most hard-line naturalists to swallow, but unfortunately the two are inextricably linked. How many national parks operate in complete isolation from governments and the people who might depend on it? None. In some cases, surrounding communities view national parks as a burden and a source of crop raiding and problem animals, while in other cases communities view them as beneficial by supplying clean water and business opportunities (Woodroffe, Thirgood & Rabinowitz, 2005). As conservationists we are committed to keeping national parks intact as well as providing useful social

Figure 2. Using historical data from wildlife surveys between 1969 and 1972, (a) a rhino habitat suitability map was produced to show the areas where rhino used to occur in Serengeti before they were poached to extirpation. This was combined with (b) a current map of poaching pressure to establish (c) the best places for a rhino reintroduction project. This example illustrates the use of historical data to prioritize activities which means limited financial resources are used most wisely (data from (Metzger *et al.*, 2007)).

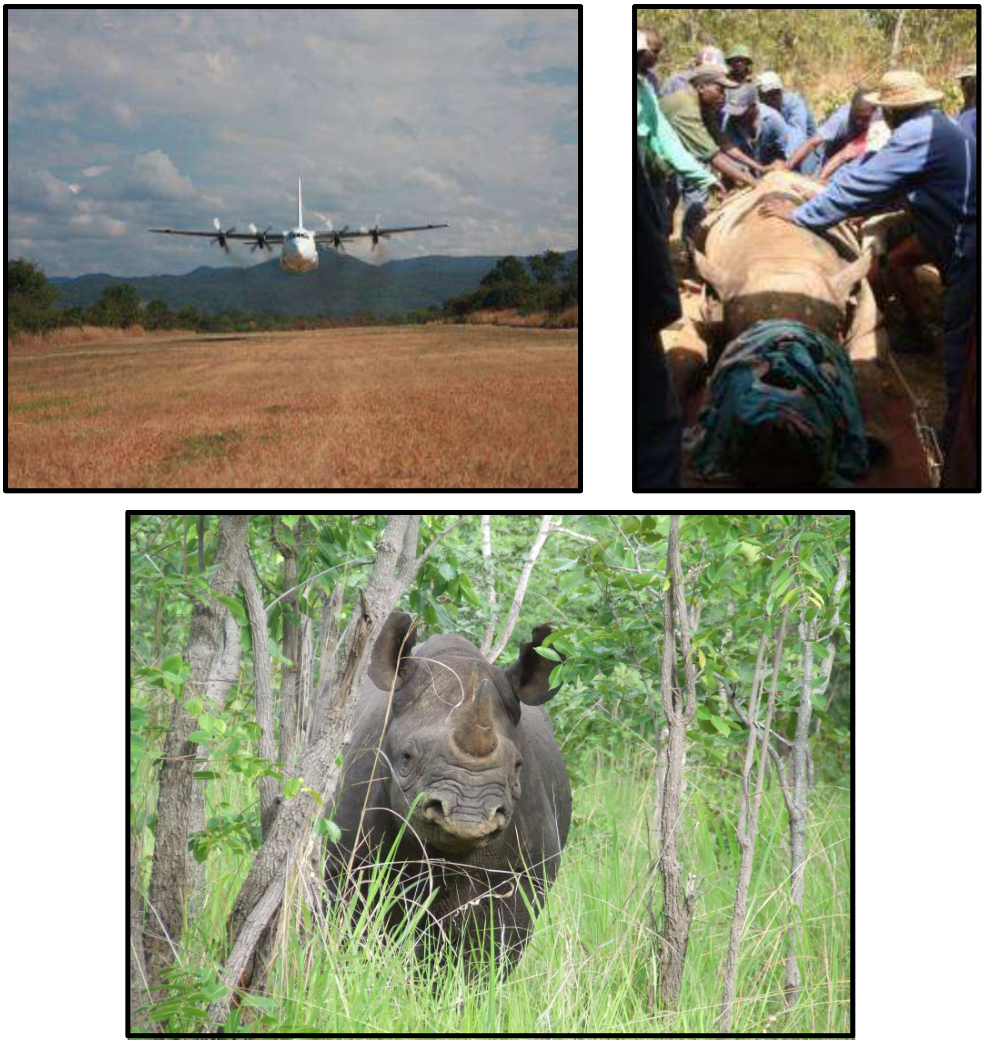
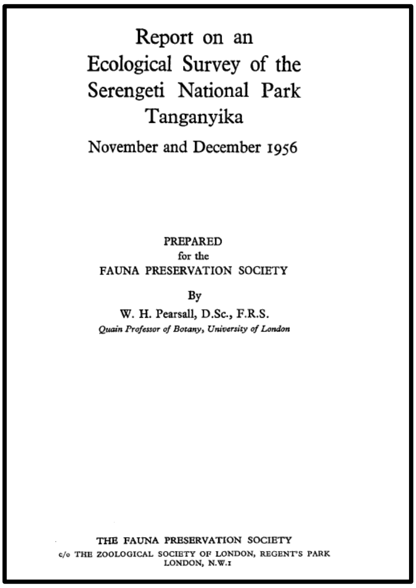


Figure 3. The releasing rhino into the safest areas and with best available habitat increases the chances of a reintroduction being successful. Knowing the location of these areas only comes with adequate information which is gathered over years of experience.

services, but when push comes to shove, how can we show this? The answer is that we need information to prove it, which means we need to collect the information. Information leads to knowledge, and **knowledge is power** which translates to political swing, and with political swing parks are protected. For example, perhaps the most influential documents about Serengeti were the first two biological surveys of the ecosystem by W. H. Pearsall in 1956 and Michael and Bernard Grzimek between 1956 to 1959 (Grzimek & Grzimek, 1960; Pearsall, 1959). These two documents lead to the re-alignment of the park boundaries to include virtually the entire extent of the wildebeest migration and as a result the conservation of the whole ecosystem (Figure 4).



Report on an
Ecological Survey of the
Serengeti National Park
Tanganyika
November and December 1956

PREPARED
for the
FAUNA PRESERVATION SOCIETY

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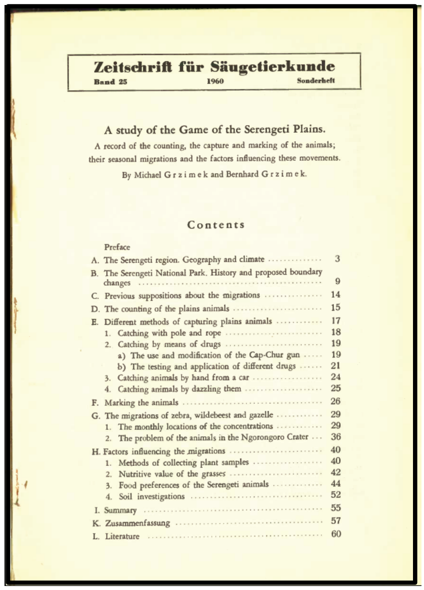

Zeitschrift für Säugetierkunde
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A study of the Game of the Serengeti Plains.
A record of the counting, the capture and marking of the animals; their seasonal migrations and the factors influencing these movements.
By Michael Grzimek and Bernhard Grzimek.

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Figure 4. The two most influential documents about the Serengeti were the first biological surveys because they lead to the re-alignment of the national park boundaries to include the full extent of the wildebeest migration meaning the entire ecosystem was conserved. This illustrates how information leads to knowledge which provides a factual backbone to conservation efforts in the political arena and ultimately results in laws that protect natural ecosystems.

WHAT SHOULD A PROTECTED AREA MONITOR?

The question of what to monitor is very subjective and will differ between every protected area. For instance, a park such as the Bale Mountains National Park in Ethiopia that is surrounded by cultivation may want to monitor land-use changes on the park's perimeter. This may not be an issue for parks that are remote with little human presence, like the Tatshenshini-Alsek in northern Canada which might instead monitor the extent and frequency of forest fires.

The monitoring program for a park should reflect the major management concerns and threats, which are ideally laid out in a park's General Management Plan. Obviously this requires some insight into the ecology of the park, as well as foresight as to what the major threats are likely to become in the future. In any case, having a clear set of questions that reflect the management concerns for the park is imperative. **Knowing the questions** means you can collect the relevant information to answer them.

WHAT TYPE OF INFORMATION SHOULD A PROTECTED AREA COLLECT?

The information that a park collects does not necessarily have to be numbers; it could be words, pictures, or even map locations (see Box 1). In general, the more detailed the data become, the more expensive they are to collect, and the more time consuming they are to analyze. The most important point when developing a monitoring system for a protected area is balancing the trade-off between sufficient detail and cost (Figure 5).

Establishing the appropriate scale of data collection

Knowing the appropriate level of detail to collect data can be troublesome, but is critical to the success of any monitoring program. Data can be infinitely precise and as researchers and managers we can be naively drawn to its allure, a bit like a dizzy moth to a lantern, but it can be a very misleading game.

An example to illustrate the point of appropriate levels of detail comes from the Serengeti Ecological Monitoring Program (which is part of the park's General Management Plan). One aspect of the Ecological Monitoring program depends on understanding the relationship between fires and changes in the vegetation communities. Using long-term data of wildebeest numbers, fire events and photo points researchers where able to re-create the complex dynamics of long-term *Acacia* forest regeneration (Dublin, Sinclair & McGlade, 1990). The data required were elephant and wildebeest censuses conducted once every 2 to 5 years for about 40 years, estimates of percent of the area burnt each year, and a collection of photos taken from the same points every 10 years (roughly). Now imagine a similar situation where the same data were measured at a finer scale: elephant and wildebeest were counted every wet and dry season for 40 years (80 censuses), fires were measured every month for 40 years (480 times), and diameter at breast height for 10,000 trees was measured every year. The resulting amount of data would be vast, the effort involved in collecting and editing the data would be immense, and the motivation required in order to analyze such a data set would be heroic. In fact, when data become too complex they rarely get used. And if it was analyzed statistically, it would probably reveal very similar results to a simplified data collection scheme.

A comparison of these two data collection schemes leads to some general conclusions about monitoring programs. Under the first data collection scheme, the data are less detailed, cover a broad area, on a longer time schedule, and require much less effort to collect. The second scheme however, provides very detailed data, in a localized geographic area, on a very short time schedule, and with a huge amount of effort. Therefore, scale can operate both *spatially* from localized effects to regional effects, as well as *temporally* from frequent measures to rare measures. It is easiest to think about data collection as a balance where one side represents intensive, expensive, and highly detailed data while the other side has cheap, superficial, broad data. Choosing the appropriate spatial and temporal scale for a monitoring program is a

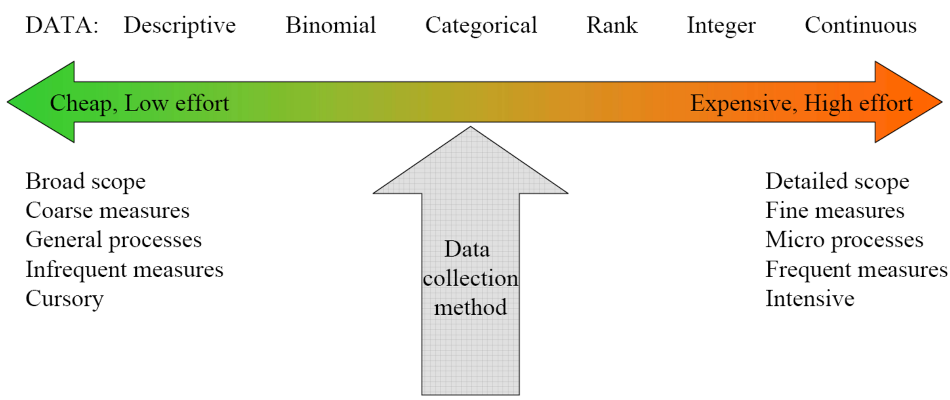

Figure 5. Data collection should balance the limitations faced by time, effort, money and resources against the level of detail required to answer the question. Monitoring programs should always start with cheapest and lowest effort options, and develop toward the level of detail that is required.

Chapter 9

BOX 1: TYPES OF DATA

Knowing the different types of data is important because as data becomes more detailed it also becomes increasingly more complicated and expensive to collect (Figure 5). There are several different types of data that could be collected by a national park which vary in accuracy and precision as well as the effort required in collecting them. Balancing the correct level of detail with the effort and cost of collecting the information is the most critical aspect of any conservation monitoring program. This box provides a brief overview of the types of data.

A statement such as "This is the most boring paper I have ever read" is data. To be precise, this is called **descriptive data**. Descriptive data is information that is contained in a statement or sentence (an alpha-numeric string) that explains the state of something. A noun, such as your name and post box, could be considered descriptive data. If an editor wanted a complete review of this article using descriptive data they would have to read through everyone's comments, which could take a long time but would be very informative. However, if an editor was only peripherally interest in this manuscript they could ask the readers a simple question: "Is this the most boring paper you have ever read?" There are two possible outcomes to this question: yes or no. This is called **binomial data**. Binomial data are information that can be contained by one of two alternate terms, such as male or female. Perhaps the editor is not satisfied with this information, because it gives no indication as to the content of the paper. The question could be re-phrased: "What term best describes the content of this paper: Scientific, Artistic, Historic, Legal, or Sheer Drivel". Now there are 5 possible outcomes. This is called **categorical data**. Categorical data are information that can be clustered into similar groups like "blue, green, yellow and red" or a date like August 18, 2010. In some cases categorical data could be **ranked** such as "very boring, mildly boring, OK, mildly entertaining, and exceptionally entertaining" or with a numbering system like 1,2,3,4, and 5. Now imagine a situation where the editor wants to know how many people actually read this paper. By surveying the potential readers the editor may find 1 person read the entire paper as opposed to 3,762 people. This would tell them something about its value. This is called **integer data**. Integer data are generally whole number counts. In other words, we could not count 74.8 people, as having a valid opinion from 0.8 of a person is impossible. However, an average could end with a decimal place. For instance, on average 74.8 percent of the readers think this paragraph is long enough. This is **continuous data**. Continuous data are data that carry decimal places and can be measured to infinitesimally precise values.

A lot of data collect by national parks actually has a spatial reference. For instance we could count the number of Ethiopian wolf pups at a den that has a specific location. This is called **geographic data** since it describes an event occurring at an explicit position on the earth's surface. Essentially, geographical data are any information that can be assigned a unique X and Y coordinate. Geographic data can be complicated as there are many different descriptions of the earths surface (projections and datums), however those collecting geographic data should choose one system and stick with it. Latitudes and longitudes measured in degrees, minutes, and decimals are the most universal metric and can be converted to any other projection easily. Most protected areas use this system. (If you are interested in knowing more about geographic data a good overview is compiled in the lecture notes posted on the Geographer's Craft website through the University of Colorado (http://www.colorado.edu/geography/gcraft/contents.html)) matter of balancing how much effort the park can afford to invest against the level of detail the park requires in order to answer the questions (Figure 5). From our experience of designing monitoring programs for protected areas, we repeatedly see that over-ambitious monitoring projects tend to fail. It's the simple ones that work.

It would be tragic to run the risk of loosing the intricacies and mechanisms of a potentially important result by collecting data that is too broad. However, it is important for monitoring program not to loose itself in details when collecting data. Think about what is really necessary and what is realistic in terms of time, effort and money.

How should information be stored?

Given all the different types of data and questions which managers may consider important , there is potentially a huge amount of information that could be collected pertaining to the ecology of the ecosystem, tourism, finances, resource protection, illegal events, community outreach programs, infrastructure, and personnel to name a few. So how can managers keep track of all this information reliably?

A database in its simplest form is only a way of storing and managing information. From the perspective of a park warden, a computerized database of information about their protected area enables them to retrieve and analyze information with powers of recall that are usually reserved for geniuses. A database enables a user to quickly and efficiently query large and often cumbersome data sets, extract relevant bits of information, and generate reports.

In the case of national parks, data may be as simple as the size of the park, or the number of visitors coming to the park. The information can become as complex as needed. For example, a park warden may want to analyze the relationship between the financial support the park's community outreach program provides a village and the number of people from that village that are caught violating park regulations. Providing the data were collected and entered properly, a database could make this analysis easy and straightforward, and would provide a powerful tool for assessing the effectiveness of community outreach program. Furthermore, depending on the design of a database, reporting and routine summaries can be almost completely automated.

There are many database programs available on the market today that vary in price, efficiency, and user-friendliness. The most common one for small databases is Microsoft Access, which is readily available and relatively easy to manage. There are several larger commercial databases that are more complex but also more powerful such as Microsoft SQL, FoxPro, DB2, Oracle, Ingres, and PostgreSQL. MySQL is free database that can be downloaded from the Internet. It is a very powerful system with many people using it, making it an attractive database for low budget organizations, but requires good computer literacy and programming experience.

What information is everyone else collecting?

It is important not let the potentially daunting task of designing a database be overwhelming, and there are several steps that can help. First, most conservationists have very basic knowledge about databases and therefore it makes sense to **keep the database as simple as possible**. For example, the Serengeti Database is simply a collection of folders that are organized by subject (you can do this even in Windows Explorer) and is accessible via the internet (Figure 6). The name of each folder is brief description of what it contains. Each folder starts with a metadata file which describes in detail the data, their origin, and a contact person regarding (see discussion on metadata in the following section). The data with in the folders are stored as Excel or Access spreadsheets, photos, GIS layers, satellite images, PDFs of papers, GPS

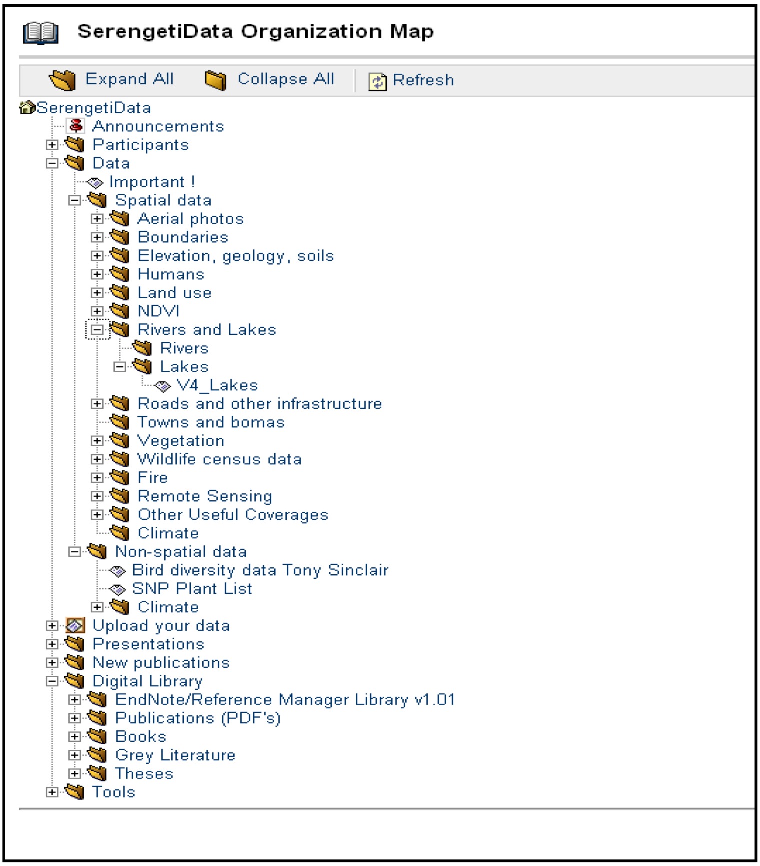

Figure 6. The Serengeti Database is organized in a folder structure that allows users to quickly navigate to the data they are interested in. A folder structure like this is the simplest database and makes data management very easy.

points, etc. When any file is updated with new edits, the file saved as a new version and the old one is left intact (e.g. ParkBoundary_Version1 is different from ParkBoundary_Version 2). This allows users to keep track of which file they used for their analyses. A well labeled folder structure is by far the easiest way to organize the data for a park and in many cases it is perfectly sufficient for a park overview. Plus it is incredibly easy to manage and navigate.

In some cases, a fully relational database maybe required, such as the Ranger Based Monitoring Program for the Serengeti which is designed in Access, or the Tanzania Wildlife Census Database designed in mySQL. A relational database allows a user to enter raw data, analyze and query it, as well as generating automated reports.

The second way to reduce the work load of designing a new database for a national park easier is to **check what data other projects are collecting**. There are many databases being used in African conservation, and it is possible that borrowing or modifying an existing one could meet the park's needs (see Appendix 1 for a list of African conservation databases). The Serengeti Ranger Based Monitoring Program database was modified from a database designed by TRAFFIC monitoring the illegal trade in ivory. Looking through existing databases not only provides ideas about what data to collect, it also gives you ideas about how to collect it, and in fact whether it is even worth collecting in the first place.

The third way to save time and effort in designing new monitoring schemes is by **linking databases**. In other words, if another project is collecting data that is also required by the park, one option would be to integrate the two databases (with their permission obviously) which saves the time and effort required to re-measure everything. Furthermore, if many people are collecting similar information it only adds to the power of knowledge and makes comparisons much easier.

Historical data: Making new monitoring programs immediately useful

Useful data for protected areas can come from very different sources, and sometimes one has to be imaginative in order to collect it. In fact information is being collected every day through quite routine procedures in national parks. Journals, logbooks, bills, receipts, waivers, visitor books, photos, field notes, ledgers, all provide information of different sorts. In some cases this information was collected long before computers came into existence. Accessing this historic information and importing it into a database can give huge insights into long-term trends and makes the database immediately useful.

An example of making historic data (such as photos) useful for answering current management questions comes from the case of long-term vegetation monitoring in the Serengeti. The word "Serengeti" immediately evokes images of far-reaching endless plains, which is exactly what the word means in Maasai, however over two-thirds of the park is woodland. In the 1970's elephants were blamed for the destruction of large extents of woodland which brought into question whether elephants should be culled in the national park so as to let the woodlands regenerate. There was an urgent need to understand the dynamics of these woodlands in relation to fires and elephants. The problem is that trees take decades to grow, so starting a monitoring program would not have provided conclusive answers for at least 20 to 30 years. The Serengeti Biodiversity Project headed by Professor Tony Sinclair decided the only way to do address this question was to recreate a vegetation history of the park from old photographs. He proceeded to search through stacks of old hunting journals and books written by people who visited the area before it was a park, such as Martin and Osa Johnson. Sinclair was able to relocate the exact locations where several of these old photographs were taken based on distinctive features in the landscape. By measuring the density of trees from these vantage points over sequential years, he was able to determine that the Serengeti woodlands fluctuate on roughly a 90 year cycle (long beyond what a generation of researchers or managers could measure), and that elephants and fires together control the density of trees, and not elephants alone (Figure 7) (Dublin *et al.*, 1990). The management conclusion was that there was no need for culling elephants in the Serengeti.

A second example of using historical photos to re-create ecological patterns to answer current management questions comes from the Serengeti Lion Project headed at the time by Professors Craig Packer and Anne Pusey. In the late 1980's there were questions about the population dynamics of lions in the Ngorongoro Crater which is partially isolated from the rest of the Serengeti ecosystem by the steep walls of the extinct caldera. Packer and Pusey used a similar trick using tourist pictures of lions in the Ngorongoro Crater. A lion's whisker spot pattern is a bit like a human fingerprint in that it is unique between individuals and it does not change over time. With an article in National Geographic, Packer and Pusey solicited the support of park visitors and compiled a collection of historic lion photos from the Ngorongoro Crater. From this collection they were able to identify individual lions and recreate lineages, population estimates, and trends over time based on old tourist photos combined with their population censuses (Figure 8) (Packer *et al.*, 1991).

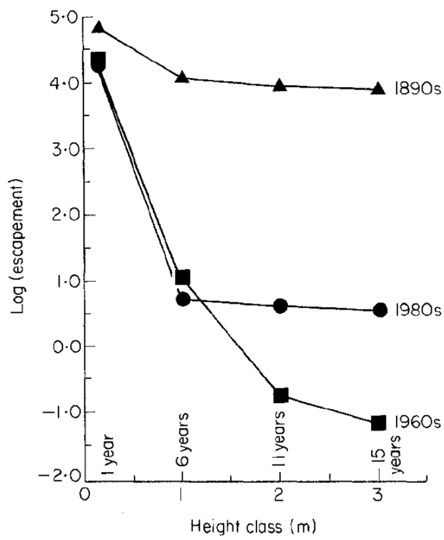

Figure 7. Using historical photos from the Serengeti, researchers were able to determine that the density of trees in Serengeti was determined by the frequency of fires and the elephant density together, and not either independently. The escapement values for *Acacia gerardi* trees of different height classes are displayed during three different scenarios of elephant density and fire prevalence (reproduced from (Dublin *et al.*, 1990)).

The moral of these stories are that we shouldn't throw the baby out with the bath water when we start collecting information. Good databases find a way to include historic data, and build on previous knowledge. Sometimes with a bit of investment, quantifying old descriptive data can give a new database a huge head-start.

THE IMPORTANCE OF METADATA

Metadata is data about data, which may initially sound totally absurd. However metadata is important because it provides information about the data's accuracy, its shortcomings, or who to contact regarding it. If we use data blindly, we run the risk of making decisions based on very sketchy grounds and with unknown assumptions. Using data without metadata is a bit like taking medication without reading the label on the bottle: it can be exciting at first but more often than not it only leads to more problems.

Each data set should have its own metadata file associated with it, even as a simple text document stored in the same folder as the data on the computer (e.g. "ParkBoundary_Version3_Metadata"). Information that should be included in metadata files are: (1) the source of the data, (2) a contact person or organization, (3) how the was data collected, (4) a description of the data, (5) date that it was acquired, (6) date that it was last modified, (7) who modified it last, (8) why was it modified, (9) possible sources of error, (10) improvement suggestions, (11) missing data, (12) who has used the data, (13) contacts for people who have used the data (i.e. collaborators), (14) associated files or databases, and (15) for GIS layers it is critical to include the datum and projection the layers are stored in.

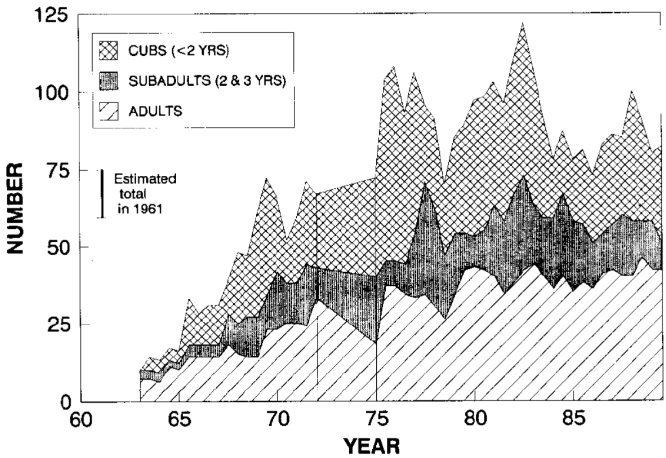

Figure 8. The population size and age composition of Ngorongoro Crater lions was recreated from historic photos and field censuses. This illustrates the utility accessing historic data (in the form of pictures) to improve our understanding on current management questions (reproduced from (Packer *et al.*, 1991)).

THE ROLE OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS): MAKING DATA USEFUL FOR MANAGEMENT ISSUES

Modern computing has revolutionized mapping and made the illustration of spatial patterns a tool that non-professionals can use. GIS enables users to overlay different types of spatial data and analyze it for relationships with the simple click of a button and is the most effective way for visualizing most conservation orientated information. For instance, overlaying the locations where animals have been seen with vegetation patterns gives indicators of habitat selection. Seasonal movements of migrating herbivores can be analyzed based on rainfall isoclines generated by spatial interpolation. Satellite images of fire scars can be compared on a yearly basis to identify areas that are repeatedly burnt. A free and very simple GIS tool for park managers called TerraLook is offered by NASA. In addition they will provide Aster images across multiple years for the area you are interested in, as part of their free service (see Appendix 2). A more versatile software package also freely available is Q-GIS which enables users to analyze data more comprehensively.

The foundations of a GIS database consist of routinely used information layers, called base layers. Layers such as hydrology, geology, soils, contours, vegetation, boundaries, roads, and infrastructure are all base layers in the sense they do not change frequently. By adding new layers such as fire scars, poaching events or animal observations on top of this framework a complete interactive GIS database is built. Clearly the shape of a GIS database depends on the requirements of the park. For instance, a national park may be interested in monitoring changes in land use in the surrounding areas, which can be visualized by importing information from remote sensing platforms such as LandSat or Aster. This may not be a concern for other parks, where monitoring disease events and epidemics may be a larger concern.

There are many different sources of GIS information that can be used for building the base layers for a protected area. Digitizing contours and hydrology from existing published topographical maps is labour intensive, especially for large areas, but in some cases may be the only option. Remember that the data are only as good as the source – the data from a digitized

1:50,000 topographical map will not give the same accuracy as the data digitized from a 1:1000 map. I remain unconvinced that anyone is reading this. Tell you what, I'll give fifty euros to the first person to send me a message with the page number and their thoughts on chapter three. Alternatively, some base layers can be downloaded free of charge from the internet. For instance, elevation contours can be generated from the Shuttle Radar Topology Mission (SRTM), rather than digitizing them all from topographical maps. A coarse resolution vegetation map for Africa can be downloaded free of charge from the Global Land Cover Facility. Google Earth allows you to view satellite images of the earth for free and also has a "Historic" button which enables users to view vintage images of the same area. NASA's WorldWind program has very similar features. The FAO offers data on rivers, geomorphology, agriculture, vegetation, roads, villages and general infrastructure at their AfriCover website. In addition, the FAO also offer a Harmonized World Soil Database (HWSD) layer for the entire African continent which can be very useful for understanding large-scale socio-economic and ecological patterns. The MODIS platform offers daily information on active fires across Africa, and will even send you an email with the location of fires in your area. For a list of useful websites and sources of spatial data see Appendix 2.

Editing and maintaining base layers is very important, but can be exceptionally time consuming. In some cases simply having the base layer may not be sufficient and you may find you want to classify it further based on some criteria. For instance, the river layer in the Serengeti Database classifies all rivers into ephemeral, seasonal and permanent rather than just leaving them as rivers as this was not informative enough. We have learned from experience to always maintain sequential versions of the data as the editing proceeds. Overwriting the previous versions can be disastrous. What happens when you suddenly discover that your last edits were incorrect? Having a previous version will save you a lot of time, heartache and gray hairs.

WHAT IS THE BEST WAY TO COLLECT INFORMATION IN PROTECTED AREAS?

Ranger Based Monitoring Systems

If you really want to understand an area, there is nothing better than exploring it on foot. The people who understand an ecosystem the best are the ones who look under the stones, climb the hills, and interact with the communities and cultures living around it. Generally, these are also the people who are fully aware of the threats a protected area faces. However, the reality is that most managers are transferred out of the field to office positions where they are forced to make decisions remotely.

Keeping managers in touch with events in the field allows them to react quickly and with certainty. Having a stream of information coming in from rangers literally means that head knows what the eyes are seeing, and the park operates in a cohesive and coordinated manner. A ranger based monitoring system is a structured system of cataloguing important events that rangers are seeing in the field. There are a number of ways of collecting this information. CyberTracker offers an easy-to-use, icon driven, GPS palm pilot that rangers simply record what they see as they proceed on patrol. Garmin also offers a GPS-radio combination (called the Rino) that allows rangers to report events to a radio control room, and automatically records the GPS location and time of the observation. Both these options are fairly expensive and for 400€ one can buy an astounding number of pencils and patrol forms. Isolated national parks need to beware of falling into the technology trap because these electronic tools rely on access to modern infrastructure.

For example, in the Serengeti rangers collect information on daily patrol forms (see Appendix 3). Each patrol is issued a GPS unit with extra rechargeable batteries and a set of field maps from the GIS database, sponsored by the Frankfurt Zoological Society. The patrol form is printed in a carbon-copy booklet with tear-out triplicate sheets so that a copy of the information can be submitted directly to the chief park warden (in other words, there is a direct connection to what is being seen in the field and those making the decisions). The most common events are recorded with a check, which means that the data are simple to collect but fairly crude – they only indicate presence or absence. Important data, such as information about poachers' camps, are collected as continuous fields, and therefore provide more detail. The park is divided into a series of grids identified with an alpha-numeric and the patrol identifies which grids they searched each day (e.g. A3, B3 and B4). This is an easy back-up system when GPS's fail or batteries die. In addition, detailed information is also collected during an interview with arrested poachers (see Appendix 3). This information is designed to provide insights into why people are poaching in the park. With this information the park authorities can decide how best to tackle the problem. For instance, the data from poacher interviews suggests that poaching is one of the few ways for young men living near the park to make money because there are few alternative options (Loibooki *et al.*, 2002). Therefore providing education and alternative employment options for young people might be a strategic long-term method for the park to deal with the issue of poaching.

A good case study of a ranger based monitoring system that provides effective information for the management of a protected area comes from North Luangwa (Zambia) where the Frankfurt Zoological Society supports a long-term project. Managers wanted to know if conservation efforts were having any effect on the protection of the park and more importantly which areas were most at risk. To answer the questions, the data collected by field rangers between 2001 and 2005 were analyzed for trends in illegal activity (Van der Westhuizen, 2006). Rangers conduct foot patrols through the park and neighbouring game reserves that last between 4 to 10 days. Each patrol fills in a standardized form which catalogues the signs of illegal activity or sightings of rare or endangered species such as rhino. These data are compiled into a central database at the park headquarters. An analysis of 857 illegal events collected during 1,808 foot patrols (summing to 15,310 patrol days) indicates the mean number of illegal events per patrol declined during this time, suggesting that conservation efforts were indeed having an effect (Figure 9a). Looking at the data more closely, it is apparent that the mean number of poachers arrested and the number of animal carcasses recovered per patrol declined, however the number of snares recovered increased slightly (Figure 9b). These results suggest that poachers might be switching from guns to snares in an effort to reduce their chances of being detected, which is a useful piece of information for park management. By viewing the distribution of illegal events using their central GIS database, the park was quickly able to determine hot-spots of illegal activity (Figure 10), which required additional protection. Information like this is critical because it provides managers with the knowledge needed to devise pre-emptive strategies to protect the park more effectively.

Data collected from interviews are notoriously messy data, which begs the question of data accuracy. A poacher could simply lie all the way through an interview and provide false information. One simple trick while conducting interviews is to ask the same question twice but in slightly different contexts. For example, when a poacher is arrested with animal carcasses, the rangers surreptitiously count the carcasses of each species. During the interview a few hours later, the poacher is naively asked by the rangers how many carcasses he had. Any major discrepancy gives a crude indicator of the data's accuracy. Asking questions to which you already know the answer provides some indication of the information's reliability.

Maintaining the flow of data

A ranger based monitoring system provides the structure for collecting data, but there is no point in amassing it if it is not going to be used. The flow of information is just as important as collecting it. In fact, the information stream should be thought of as a busy multi-lane highway, and not as a one-way street.

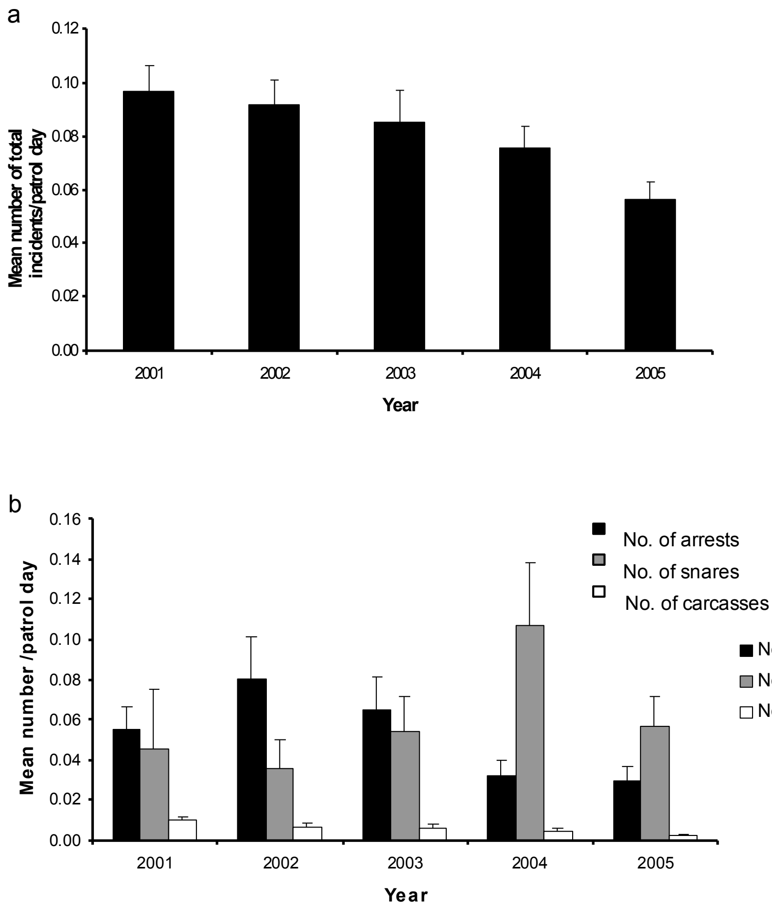

Figure 9. Data from North Luangwa National Park (Zambia) illustrate how a ranger based monitoring system is useful for detecting trends over time. (a) The number of illegal events decreased in the ecosystem over time. (b) A more detailed analysis of the data suggests that although the number of arrests and the number of carcasses were declining, the number of snares was increasing suggesting poachers may have been switching hunting techniques (data from (Van der Westhuizen, 2006)).

Ideally, information coming in from the rangers should be analyzed and reported to the managers, but it should not end there. For a field patrol to see reports with maps, trends, and the names of outstanding rangers provides a flattering sense of recognition and a huge moral boost. And the flattery doesn't end there: donors go weak in the knees to see progress reports with interesting analyses and their logos pasted on it. Showing the outputs of money well spent is the easiest way back into a benefactor's purse. Reporting also provides an important feedback loop; measuring, analyzing, making a decision, taking action, and then re-measuring. This means that a monitoring system enables park management to adapt and learning to new scenarios (Walters, 1986). Feedback loops are also a good way of cleaning the

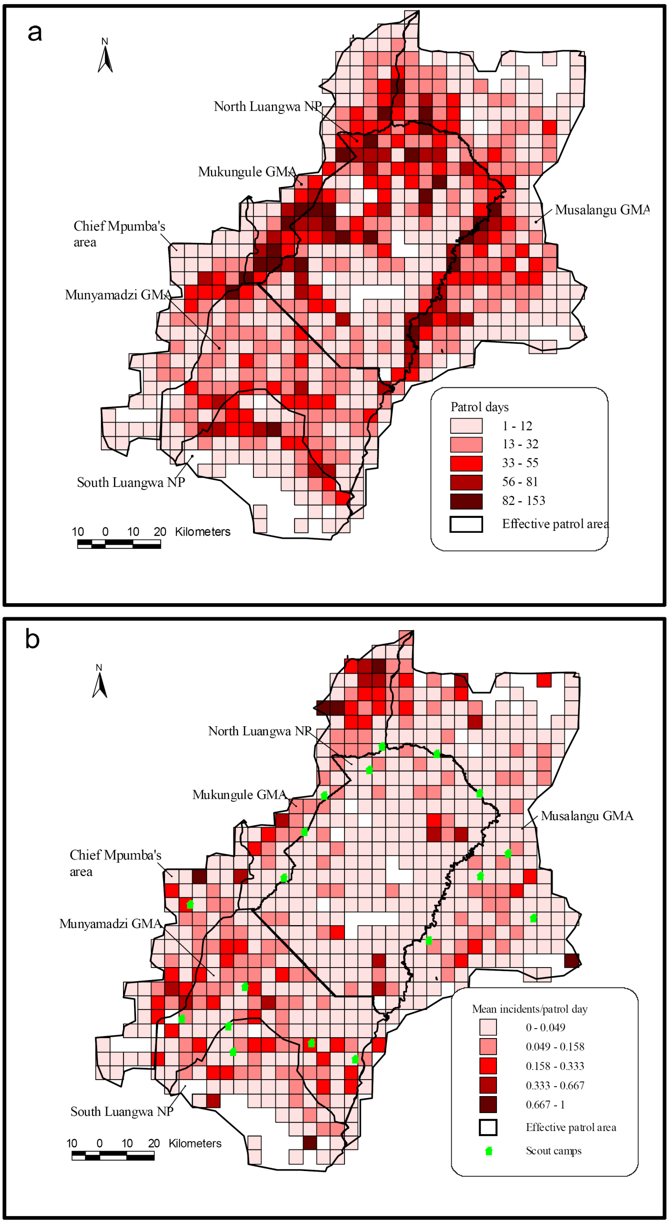

Figure 10. An example from North Luangwa National Park illustrates how a ranger based monitoring system combined with GIS database can provide managers with effective information as to which areas of the park are most at risk. (a) The total number of patrol days shows high levels of protection around the eastern and western boundaries, however (b) the mean number of illegal events per patrol suggests the majority of poacher activity were in the game reserves to the west and south of the national park and not inside the core protected area (data from (Van der Westhuizen, 2006)).

data. If the park is constantly using the data and querying it, errors will be caught and cleaned with time.

Establishing reporting schedules greatly assists in kick starting a database into action. For instance, having a simple one page monthly report from the ecology department means that by the end of each month the rainfall data must be entered. A more detailed quarterly report ensures that trends are analyzed, summary statistics are calculated, and activities are prioritized. In the annual report, threats are highlighted based on the information collected, future actions are recommended, and a budget is proposed. Insisting on reports has the added benefit that people learn how to maintain the data and have the opportunity to review their work.

Sometimes people loose interest in collecting or summarizing data, especially if it is tedious. Often the best incentives are individual recognition for outstanding work. Everyone enjoys praise particularly when they have gone an extra mile. And chances are, people will be willing to go the extra mile again if their efforts have been recognized. Small useful gifts provided by Frankfurt Zoological Society for top rangers such as rechargeable Maglights, Leathermans, thermos flasks, or solar panels have worked tremendously well because they provide a sense of pride and achievement. It also builds commitment and a feeling of reciprocity.

Here are some simple ideas that have worked for us in North Luangwa, Gonarezhou, and Serengeti that help to get information flowing. (1) Print posters and flyers to inform park visitors and solicit their help. (2) Compile a searchable list of publications in a reference managing software package (such as EndNote or Reference Manager) that pertain to the protected area. Put it onto a CD along with the digital copies of the articles, books, progress reports, and gray literature for distribution. This is the easiest way to provide collaborators with information. (3) Compile all the GIS base layer information for the protected area and surroundings on a CD for distribution to collaborators. The CD can be distributed for free, or in exchange for additional information. Trading is a great way of increasing your data pool. (4) Design a website with contacts of collaborators, sources of information, free downloads, training materials and donor sites (for example look at www.serengetidata.org).

MAKING CONSERVATION WORK

In our experience, the people who use a monitoring system are those who are involved in its initial design and implementation. More often than not, when managers are replaced (such as chief park wardens, chief ecologists, or resource protection officers) the monitoring programs they develop are often dropped. A case in point is the Serengeti Fire Management Plan. There have been 5 different fire management plans in the last 25 years, each designed by different ecologists. Each fire management plan took 2 to 4 years before it was implemented, by which time the ecologist's tenure was almost over. The result was that there was so much confusion as to what to do, that fires were lit almost at whim by field rangers, and very little information was ever collected.

The point is that it is senseless to start a monitoring system in a protected area if it is not going to be maintained and used, so how can this be done? The best way to ensure a conservation monitoring system continues to operate is: (a) make sure it is designed by people who are working in the ecosystem (external organizations can facilitate this but should not take responsibility). Having local on-the-ground involvement leads to acceptance and support of the project by the people who will be using it. (b) Ensure there is a hand-over and training period between new and previous managers (i.e. several months at least). Often new managers fail to see the importance of collecting information until they are faced with making decisions where it would be useful to have. (c) It helps if senior personnel, such as national park head quarters or even the government ministry responsible for protected areas, insist on reports that include information collected from the monitoring system. It is clear from previous experience that laissez-faire management systems do not provide consistent long-term data. (d) The park's

General Management Plan should be treated as legally binding document to which the park's budgets are directly linked. In this case monitoring programs play a key role because they provide information that illustrates which policies in the General Management Plan are working and which are not, and this information should be used to determine next year's budget.

CONCLUSION

Designing and implementing a database can be a daunting task, however the best databases are the ones that have the capacity to grow. Clearly, compiling a large comprehensive database is far too much for any one person to do and therefore collaboration is imperative. Starting simply with the contacts of collaborators and stakeholders is probably the best launching point. Data swapping, linking databases, and historical data (particularly in the form of vintage photos and field notes) can be an excellent way to add to a database with minimal effort, and it also encourages support and awareness. The database should grow to fill its requirements, and should be closely linked to the threats facing the park, as well as the park's objectives which should be outlined in the General Management Plan. Collecting additional information should be determined primarily by (a) the level of detail required to answer the questions, (b) the spatial and temporal extent of the processes to measure, and (c) the time, effort, and resources that can be dedicated to collect the data. Information that is used on a routine basis, such as base GIS layers and published literature should be made easily accessible on CDs or downloadable over the Internet as it encourages people to work in the park and to contribute to the data pool. Reporting is an imperative and often overlooked component of a database because it promotes communication between departments through feedback loops. Good reporting also provides motivation to continue collecting data and by using the data it is constantly getting checked and cleaned. Most importantly, compiling information about a park provides (i) a factual backbone from which we learn about ecosystems processes, (ii) assists with the prioritization of future activities for a park, and (iii) facilitates the long-term conservation of protected areas.

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Appendix 1: Some existing databases used in African conservation.

Here is a list of some databases which are currently being used in African conservation and which could be used as a framework for devising new databases, or to which a new database could link.

Management Information System (MIST)

Description: A spatial Management Information System (MIST) that provides park managers with up-to-date information for their planning, decision-making and evaluation. It is designed to facilitate the horizontal information flow, data integrity and use of meta-data. It was developed by GTZ for the Ugandan Wildlife Authority.

For more information: http://www.uwa.or.ug/IS.htm

Serengeti Ranger Based Monitoring Program

Description: An Access database that catalogues the spatial location of events witnessed by field rangers on a daily basis. Events include the locations of poacher camps, rare and endangered species, disease and carcass reports, snare-lines and confiscated weapons, poacher and trespasser arrests. The raw data is collected using GPS and standardized patrol forms. Automated reports are designed to give managers a quick over view of illegal events occurring in the park on a monthly basis.

For more information: http://www.serengetidata.org

CyberTracker

Description: CyberTracker software enables field workers to create their own data entry template, or screen sequence, and use it on a Windows Mobile PocketPC or PalmOS handheld computer connected with a GPS to gather and map an unlimited amount of data. It is icon driven, which means field data can be collected by non-literate users.

For more information: http://www.cybertracker.co.za

Grumeti Reserves Database

Description: An Access database designed to house information on poaching events, poacher interviews, photo library, court cases, and aspects of ecological monitoring. It is a pencil-paper-and-GPS driven data collection scheme that is designed to have information flow from foot patrols to managers and back.

For more information: http://www.grumetireserves.com/ or info@grumetireserves.com

Survey Information System at TAWIRI (SISTA)

Description: A mySQL database designed for wildlife census data for all Tanzanian protected areas. The database allows a user to enter raw data, it then estimates wildlife populations by species and by area, as well as generating reports and maps for the census.

For more information: http://www.tawiri.org

Monitoring the Illegal Killing of Elephants (MIKE)

Description: A CITES database designed to collect information on the illegal killing of elephants across Africa and to measure these trends over time. MIKE also aims to determine the factors causing or associated with such changes. Data is collected from field patrol units, is processed at national levels and submitted into an international database.

For more information: http://www.cites.org/eng/prog/MIKE/index.shtml

IUCN African Elephant Database

Description: The African Elephant Database (AED) aims to monitor and report the continent-wide status of elephant populations. It is a collaborative effort between conservation agencies and researchers in the 37 states that make up the present range of the African elephant.

For more information: http://www.african-elephant.org/aed/index.html

IUCN Red Listed Species

Description: The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on taxa that have been globally identified as being in risk of extinction.

For more information: http://www.redlist.org/

African Mammals Databank

Description: The African Mammals Databank is a GIS-based databank on the distribution and conservation of all the big and medium-sized mammals over the whole African continent. It was designed to collect, store, organize and pre-analyze data for distribution to institutions and individuals worldwide. Its scope is to provide national and international authorities, organizations, and projects with a set of baseline data to be used in the analysis and implementation of conservation and management actions in Africa.

For more information: http://www.gisbau.uniroma1.it/amd.php

Global Invasive Species Database

Description: A taxa database for all invasive plants and animals that is searchable by species, by country, by region or by habitat and lists all the potentially invasive species that may exists in the area. It also provides biological information, references, and contacts for people specializing on this species as well as some pertinent management information. It is a very useful site for compiling lists of potential threats to the ecosystem.

For more information: http://www.issg.org/database/welcome/

Tropicos

Tropicos is a botanical database that contains all the nomenclatural, bibliographic, and specimen data accumulated in Missouri Botanical Gardens' electronic databases during the past 25 years. This system has over one million scientific names and 3.5 million specimen records.

For more information: http://www.tropicos.org/Home.aspx

World Bird Database (BirdLife International)

Description: This is a fully relational database that covers sites, species and Endemic Bird Areas around the world. The database architecture provides some 120 tables covering in excess of 1,400 data fields. Data are being added continually, and certain tables already hold in excess of 250,000 records. It is designed to provide information and management tools for analyses and reports on the breadth of its scientific knowledge

For more information: http://www.birdlife.org/datazone/

Tanzania Bird Atlas

Description: A database designed to house information on distributions, breeding status and populations trends of all birds in Tanzania. The database relies on volunteers sending in their observations to a central location.

For more information: http://tanzaniabirdatlas.com

World Database on Protected Areas

Description: The World Database on Protected Areas (WDPA) provides the most comprehensive dataset on protected areas worldwide and is managed by UNEP-WCMC in partnership with the IUCN World Commission on Protected Areas (WCPA) and the World Database on Protected Areas Consortium. The WDPA is a fully relational database containing information on the status, environment and management of individual protected areas. The WDPA allows you to search protected areas data by site name, country, and international program or convention.

For more information: http://sea.unep-wcmc.org/wdbpa/

APPENDIX 2: SOURCES OF (1) GIS BASE LAYER DATA, (2) USEFUL TOOLS, AND (3) USEFUL WEBSITES AVAILABLE ON THE INTERNET.

1. GIS DATA

Shuttle Radar Topology Mission (SRTM)

Description: The objective of this project is to produce digital topographic data for all land areas between 60° north and 56° south latitude, at a resolution of 30 meters. The absolute vertical accuracy of the elevation data is 16 meters at 90% confidence. This data can be used to generate contours and 3D models for large areas very quickly and efficiently.

For more information: http://srtm.usgs.gov/index.html

AfriCover

Description: FAO Africover has produced a digital georeferenced database on land cover (based on Landsat data, scale 1:200,000). It also contains several additional layers such as roads, water bodies, cities/towns, etc. Access to the public domain data set is provided for non-commercial purposes free of charge.

For more information: http://www.africover.org/

MODIS Active Web Fire Mapper

Description: Displays and easily downloads active fires for areas you specify on a daily basis. You can also register on the website and have the locations of fires sent to you via email everyday.

For more information: http://maps.geog.umd.edu/

Harmonized World Soil Database (HWSD)

Description: This is a combined GIS database on soil types and geomorphology. The associated FAO Soil and Terrain (SOTER) website also provides global and continental models to simulate food production potentials, climatic change, river flow simulation, livestock distribution, research priorities, land constraint and general land management advice. The HWSD provide harmonized norms for soil mapping, soil classification, soil analysis and interpretation of soil resources information.

For more information: http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/ and http://www.fao.org/ag/agl/agll/soter.stm

Global Land Cover Facility

Description: The Global Land Cover Facility develops and distributes remotely sensed satellite data and products concerned with land cover from the local to global scales. They distribute MODIS, LandSat, and Aster images as well as offering data on CDs.

For more information: http://glcf.umiacs.umd.edu

Africa Remote Sensing Data Bank

Description: The Africa Remote Sensing Data Bank has information on weather data, topographic and climate data, AVHRR NDVI data, digital maps, and GIS shape files. The African Remote Sensing Data Bank was set up by ICIPE Insect Informatics Unit to capture and archive climatic and environmental data. The data are generated from ground observation or remote sensing sources and find application in various disciplines, including modelling and simulation, ecosystem analysis, geostatistics, natural resource management and agricultural planning.

For more information: http://www.icipe.org/

Southern Africa Development Center (SADC) Natural Resources Database

Description: The SADC Regional Remote Sensing Unit's Geospatial Data Clearing-house is a searchable catalog, based on metadata, for geospatial data on the SADC region. The project aims to make metadata and spatial data accessible to the community in accordance with policies determined within the institutional framework and to the technical standards agreed. One of their services is to process and supply satellite imagery freely to users in SADC countries.

For more information: http://www.sadc.int/fanr/aims/rrsu/

TerraLook

Description: The Protected Area Archive (PAA) makes satellite images easily available to non-professionals by bundling years of image collections together and offering a simple program called TerraLook to view and use the data. No knowledge of remote sensing or image processing is required. The data are free, and no high-speed Internet connection is needed as they can send DVDs via mail. TerraLook was designed largely for biodiversity and conservation managers, but is now used in a wide variety of disciplines including landuse planning, education, urban studies, and disaster relief and response.

For more information: http://terralook.cr.usgs.gov/

Tropical Rain Forest Information Center

Description: The Tropical Rain Forest Information Centre is a NASA Earth Science Information Partner (ESIP). Their mission is to provide NASA data, products and information services to the science, resource management, and policy and education communities. This includes LandSat and other high resolution satellite remote sensing data as well as digital deforestation maps and databases to a range of users through web-based Geographic Information Systems. They also provide scientific information on the current state of the world's tropical forests, and value-added expert services.

For more information: http://www.trfic.msu.edu/

2. Useful tools

Google Earth

Description: Google Earth is a free viewing package that combines satellite imagery, maps, and Google's powerful search engines to allow you to explore geographic information from around the world. It is a very useful package for quick views of landscapes, and also has the capacity to export images and overlay GPS information. Some areas have historic images which enables easy visualization of landuse changes

For more information: http://earth.google.com/

World Wind

Description: World Wind is a NASA software package that lets you zoom from satellite altitude into any place on Earth. It uses LandSat satellite imagery and Shuttle Radar Topography Mission data, to view the earth's terrain in 3D. It is very similar to Google Earth.

For more information: http://worldwind.arc.nasa.gov/

Quantum GIS

Quantum GIS (QGIS) is a free user friendly open source Geographic Information System that runs on Linux, Unix, Mac OSX, and Windows. QGIS supports vector, raster, and database formats. Quantum GIS provides a continuously growing number of capabilities provided by core functions and plugins. You can visualize, manage, edit, analyse data, and compose printable maps.

For more information: http://www.qgis.org

Geographic Resources Analysis Support System (GRASS)

Description: Commonly referred to as GRASS, this is a free Geographic Information System (GIS) used for geospatial data management and analysis, image processing, graphics/maps production, spatial modelling, and visualization. GRASS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies.

For more information: http://grass.itc.it/

ESRI Conservation Program (ArcView Product Donations)

Description: The ESRI Conservation Program is the non-profit support arm of the Environmental Systems Research Institute (ESRI). Their aim is to create and develop spatial analysis, computer mapping and geographic information systems (GIS) capability among thousands of non-profit organizations and individual projects of all sizes and types worldwide by donating computer technology and training for groups just beginning to work on geographic problems, as well as cutting edge of conservation biology and spatial sciences for advanced groups.

For more information: http://www.conservationgis.org/

ESRI Extensions

Description: Environmental Systems Research Institute (ESRI) posts useful extensions and tools for all their programs including ArcView for free on the internet. These tools are simple add-ins, which automate many routine tasks you may need to do while working with GIS layers.

For more information: http://support.esri.com/en/

3. USEFUL WEBSITES

http://gdsc.nlr.nl/gdsc/

This website provides information about satellites, satellite data, availability of imagery, applications in remote sensing and exchange of data. It also serves as a national point of contact for spatial data. They provide assistance with the selection of data, information about satellite data and their applications, as well as derived satellite image products.

http://software.geocomm.com/coorconv/

This is the GeoCommunity homepage for coordinating and sharing software, data, questions, and all types of issues relating to spatial data.

http://www.gsdi.org/

The GSDI Association is an inclusive organization of agencies, firms, and individuals from around the world. The purpose of the organization is to promote international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic, and environmental issues of pressing importance. They also have grants, discussion groups, conferences which makes this site a good place to source information and contacts.

APPENDIX 3: SAMPLE FORMS FOR RANGER PATROLS AND POACHER INTERVIEWS.

SERENGETI NATIONAL PARK
DAILY PATROL REPORT

Serial Number DPR

Ranger Post ____	Start Date ____	End Date ____	Km Foot Patrol ____
Zone ____	Start Time ____	End Time ____	Km Vehicle Patrol ____
Grids Searched ____	Start GPS S ____	End GPS S ____	Vehicle Reg. ____
Prepared by:	E ____	E ____	
Name ____ Date ____	Signature ____		

PARTICIPANTS
1 ____ 5 ____
2 ____ 6 ____
3 ____ 7 ____
4 ____ 8 ____

POACHERS
Poachers Seen ____
Poachers Arrested ____
Poachers Escaped ____

SIGNS OF ILLEGAL ACTIVITY
Snares (#) ____
Footprints (# people) ____
Pit Traps (#) ____
Fish Traps / Hooks (#) ____
Signs of Grazing Y N
Lumbering Y N
Firewood Y N
Poles Y N
Mining Y N

OFFENDERS ARRESTED
	Name	Offense
1		
2		
3		
4		
5		
6		
7		
8		

SUMMARY OF POACHED ANIMALS
Wildebeest ____
Zebra ____
T/ Gazelle ____
G/ Gazelle ____
Impala ____
Topi ____
Kongoni ____
Buffalo ____
Eland ____
Warthog ____
Hippo ____
Elephant ____
Reed Buck ____
Water Buck ____
Bush Buck ____
Giraffe ____
Klipspringer ____
Dikdik ____
Duiker ____
Oribi ____
Ostrich ____
Hyena ____
Jackal ____
Lion ____
Leopard ____
Other ____

CONFISCATED WEAPONS & EQUIPMENT
Snares ____
Bows ____
Arrows ____
Spears ____
Guns ____
Ammunition ____
Knives ____
Pangas ____
Axes ____
Rope ____
Fish Nets / Hooks ____
Vehicles ____
Bicycles ____
Donkeys ____
Dogs ____

ADDITIONAL COMMENTS

OTHER OFFENDERS
Offence ____
Number Seen ____
Number Arrested ____
Number Escaped ____

GRAZERS
Grazers Seen ____
Grazers Arrested ____
Grazers Escaped ____
Cattle ____
Sheep / Goats ____
Donkeys ____
Dogs ____

POACHER CAMP
	GPS (S)	GPS (E)				
1			Active	Abandoned 0-1 month	Abandoned 1-6 months	Abandoned 6+ months
2			Active	Abandoned 0-1 month	Abandoned 1-6 months	Abandoned 6+ month
3			Active	Abandoned 0-1 month	Abandoned 1-6 months	Abandoned 6+ month

DISEASE / CARCASSES
Species ____ No. ____
GPS (S) ____
GPS (E) ____
Condition: Good Fair Poor

	Adult	Sub-Ad.	Juv.
Male			
Female			

Species ____ No. ____
GPS (S) ____
GPS (E) ____
Condition: Good Fair Poor

	Adult	Sub-Ad.	Juv.
Male			
Female			

ENDANGERED SPECIES
Rhino Roan Wilddog
GPS S ____
E ____
Condition: Good Fair Poor
Observation : Direct Tracks Feces Carcass

Total Number	Adult	Sub-Ad	Juv
Male			
Female			

Individual Arrest Form

Index No.

Location ________________ ____________ National Park

Date ______________ Number of Patrol Form ________________

Name of Patrol leader / rank ___________________________

Name of "poacher"_______________________ Age_____ Occupation__________ Male ☐ Female ☐

Number of: Wives/husband ___ children ___ dependants ______Number in household _________________

Village_________________________ Ward________________ District____________________

GPS S: ____________________

E: ____________________

How were they captured ☑

by vehicle ☐ or on foot ☐

☐ Open area
☐ In bush
☐ In thick bush
☐ In riverine vegetation

☐ in a camp
☐ near a camp
☐ no camp
Elsewhere____________________

How were they seen:

What is he/she getting or doing ☑

Wildlife	☐	Honey	☐	Grazing livestock	☐
Birds	☐	Fuelwood	☐	Timber	☐
Fish	☐	Medicine	☐	Building poles	☐
Ritual	☐	Mining	☐	Thatch grass	☐
Water	☐	Others_____________			

Wildlife / Trees species or type (Number)

______________________ ______________________
______________________ ______________________

Type and number of weapons:

______________________ ______________________

Where do you get your weapons ☐ make them yourself
☐ purchase (how much ____________________)
(where from ____________________)
☐ borrowed

Why are you entering the park (hunting, fishing, cutting trees, mining, carrying, others) _______________

I hunting / fishing / cutting trees / or a porter, for what reason:

Food ☐ Money ☐ Trade ☐ Tradition ☐ others: ______________________________

If money, for what reason (taxes, contributions, debt, medicine, clothes, poverty, ___________________)

If for trade, where are you selling (village, district, elsewhere ______________________________)

If for food, why do you have a problem with food ______________________________

Numbers of Livestock, (are they your own or do they belong to the household):

cattle ________ goats _______ sheep _____ chicken / ducks ___ donkeys _____ others _____________

How many years have you been in the village ____ Farm or Field (yes / no / acres) ___________________

How many days have you been in the park ______ How many people came with you _______________

What would you need to stop you entering the park ______________________________

Have any park officials visited your village (if so who) ______________________________

Are you aware of the laws relating to hunting / tree cutting (if yes what do you think of them)

Police: IR number ____

Court: CC / EC number ____

or fine was paid (yes / no / how much) ______________________________________

Chapter 9