GIS as a Tool for Rhino Conservation

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ABSTRACT

A Geographic Information System (GIS) is the hardware, software and personnel used for storage, manipulation and analysis of spatially referenced data. At its most basic it is simply a mapping tool, but it can also be used to relate different sets of spatial data and provides powerful analytical and predictive capabilities to assist management decision-making. The use of GIS is becoming increasingly widespread in the fields of resource management. Here, I discuss the use of GIS for rhino conservation and management. After describing different types of GIS software, I review some existing GIS uses in wildlife conservation and management, and consider some of the uses to which GIS could be put within *in situ* rhino conservation programmes.

RESUME

Un Système d'Information Géographique (SIG) renferme l'instrumentation, les logiciels et le personnel employés pour le stockage, la manipulation et l'analyse de données référencées dans l'espace. Dans sa forme la plus simple il s'agit d'un simple outil de cartographie, mais il peut également être utilisé pour mettre en relation différents jeux de données spatiales et offre ainsi des possibilités d'analyse et de prédiction considérables pour aider à la prise de décisions de gestion. L'utilisation de SIG est de plus en plus répandue dans le domaine de la gestion des ressources. Je discute ici l'application des SIG à la protection et la gestion des rhinocéros. Après une description des différents types de logiciels de SIG, quelques utilisations existantes de SIG dans la protection et la gestion de la faune sauvage sont passées en revue, puis certains des usages envisageables du SIG dans les programmes de conservation du rhinocéros *in-situ* sont considérés.

WHAT IS GIS?

The acronym GIS stands for Geographic, or Geographical, Information System. There are countless definitions of GIS (Burrough, 1990; Scholten and van der Vlugt, 1990; Maguire et al., 1991; Martin, 1996; DeMers, 1997; Burrough and McDonnell, 1998; Heywood et al., 1998). Most agree that it is "a system for capturing, storing, checking, manipulating, analyzing and displaying data which are spatially referenced to the earth" (DoE, 1987). Essentially, GIS is a tool to aid decision-makers, be they town planners, foresters, fisheries scientists or protected area managers. In practice most GISs are computer-based, and consist of four components; hardware, software, personnel and the data to be managed and analyzed.

There are a variety of uses for GIS. First, it provides a way of displaying data and making measurements within data sets (*coverages* or *layers*), such as the length of roads and rivers, the average distance between water points, or the area of a particular habitat type or animal home range. It allows spatial layers to be constructed from sample data points using interpolation techniques, for example constructing a rainfall map using data from rainfall gauges. It also permits the classification of remotely sensed data such as aerial photographs or satellite imagery, with or without reference to data collected on the ground. Furthermore, new layers can be created from the original, showing for example the distance of each point on the ground from water.

Second, GIS allows different layers to be combined, or *overlaid*, to create more complex composite displays, or *maps*. Layers may come from a variety of sources, such as satellite imagery, topographic surveys, wildlife censuses, etc. Topographic map sheets are printed examples of a collection of overlaid layers, usually including relief, habitat, rivers, roads and human settlements. Other layers that could be added include soil type, rainfall distribution, fire maps, and the density or distribution of different wildlife species.

Perhaps the greatest value of GIS is that it permits analysis using multiple layers. Layers can be combined to create new layers. For example, one could create a layer showing all areas of bushed grassland that were burnt last year, or a layer showing all areas of logged forest within 1 km of a road or river. Furthermore, relationships between layers can be examined with appropriate statistical tests (e.g. Pereire and Itami, 1991). For example, one could examine whether the distribution of an animal species is related to the underlying habitat or soil types or to anthropogenic factors.

Once statistical relationships have been established, it is possible to undertake predictive modelling and simulation using GIS. For example, if it has been found that a species' occurrence is restricted to areas within 500m of water, one could create a map in a GIS showing all the areas where the species is likely to be found. Equally, if it were shown in one protected area that rhino density was significantly related to the density of acacia woodland, one could predict the density and distribution of rhinos in a second nearby protected area, given a map of acacia woodland density in that place. These are simple examples, and multiple data layers can be used to create very sophisticated models with high levels of accuracy.

DIFFERENT TYPES OF GIS

When one thinks of GIS it is usually the software that comes to mind, since this is the core of the system. There are now many different GIS software packages on the market, including Arc Info, Arc View, Map Info, Idrisi, Atlas, Camris, Map Maker and more. These software packages are becoming increasingly cheap and accessible, as are the personal computers needed to run them.

Essentially there are two kinds of GIS software, those that use a vector system and those that use a raster system. In a vector system, items are recorded and displayed as points, lines and polygons. In a raster system the coverage, or area, is broken up into a grid of pixels of a particular resolution. Vector and raster systems both have their own benefits and costs. Vectors generally take up very little computer memory since only the points of interest need be recorded. Rasters may take up a lot of memory, since each pixel of the area is assigned a value. Vectors are better for working with lines and polygons such as roads, rivers and boundaries, and for presentation purposes, while rasters are more appropriate when dealing with less clearly delineated data such as vegetation cover or topography, and are better for spatial analysis and simulation. At DICE we have been using Idrisi, a raster based system, and Arc View, a vector based system, to provide a complete suite of capabilities. Both systems are inexpensive and can be used on any Windows-based PC computer. Both are relatively simple to use after some initial training.

GIS FOR WILDLIFE CONSERVATION AND MANAGEMENT

GIS technology is increasingly being applied to ecological problem-solving (Haslett, 1990), and over the past decade there have been an increasing number of published examples of the use of GIS for applied ecology and resource management. It is a common tool in forestry and landscape ecology, having been used for habitat classification, and to examine habitat change, fragmentation, utilization, restoration and conservation. It has been used in biodiversity management to analyze threats, the effect of climate change, and to analyze protected area coverage and representation.

Increasingly GIS is being used as a tool for wildlife conservation and management. It has

Photo credit: Matt Walpole

Photo 1. *"Natumi" watching the photographer.*

been used to examine animal home ranges, and the factors affecting their size and location (Thouless, 1996; Verlinden and Gavor, 1998; Ostro et al., 1999; Waithman et al., 1999). It has also been used to model habitat suitability (Donovan et al., 1987; Pereira and Itami, 1991; Clark et al., 1993; Boroski et al., 1996; Reading and Matchett, 1997; Waller and Mace, 1997). From this it has been possible to estimate and predict population size, density and distribution over wider areas (Yonzon and Hunter, 1991; Fabricius and Coetzee, 1992; Barnes et al., 1997; Lahm et al., 1998; Gros and Rejmanek, 1999; Pike et al., 1999), to evaluate potential habitat (Maehr and Cox, 1995; VanDeelen et al., 1997; Mladenoff and Sickley, 1998; Mace et al., 1999), and to identify and prioritize areas for protection (Smith et al., 1997; Corsi et al., 1999; Li et al., 1999). GIS has also been used to examine factors affecting population viability and longevity (Lindenmayer and Possingham, 1995, 1996), and the effects of poaching and other forms of conflict and utilization on populations (Michelmore et al., 1994; Hillman-Smith et al., 1995; Foster et al., 1997; Broseth and Perdersen, 2000). These studies have covered a range of species including elephants, wolves, pandas, panthers, deer, cheetahs, grizzly bears, primates, prairie dogs and wild pigs.

GIS and rhino conservation

In situ rhino conservation is based on security and biological management (e.g. Emslie and Brooks, 1999). Both of these issues rely on information about where rhinos are and why. Thus there is a distinct spatial element that makes data storage, presentation and analysis using GIS an appropriate approach. Moreover, spatial locating hardware such as radio and satellite collars and GPS are becoming increasingly available (Thouless et al., 1992; Thouless and Dyer, 1992; Douglas-Hamilton, 1998; Hofmeyr, 1999; Iongh et al., 1999), and these provide a ready supply of spatial data that can be used in a GIS. Equally, digital satellite data for constructing habitat and other physical layers, and digital elevation models of topography are now more accessible at low cost, and in some cases are freely available.

Although GIS has been used frequently in elephant research (Thouless and Dyer, 1992; Michelmore et al., 1994; Hillman-Smith et al., 1995; Thouless, 1996; Barnes et al., 1997; Gibson et al., 1998), published examples of the use of GIS in rhino conservation are rare. The most common use has been to measure and plot rhino home range and overlap (Huggins, unpubl.; Hearne, unpubl.; Rachlow et al., 1999; G. Chege, 2000, pers.comm.). One study overlaid black rhino home ranges onto habitat and soil layers and used regression to determine habitat preferences (Huggins, unpubl.). These examples barely scratch the surface of the potential of GIS for rhino conservation, although there may be other studies which have gone further but of which I am not aware. I would be interested to hear from other *Pachyderm* readers of the ways in which they are using GIS for rhinos.

There are at least eight ways that GIS could be used as a tool for *in situ* rhino management and protection.

1. Data storage

Monitoring rhinos generates large amounts of data, on the locations of individuals, activities, health status etc. This can usefully be stored in a GIS database for ease of access, presentation and analysis.

2. Data presentation

Simply creating hard copy maps of a rhino area with distribution, home ranges or density can be useful for two reasons. Firstly to aid in planning the deployment of human resources for security and monitoring, and secondly as a presentation aid in reports and proposals to funding organizations.

3. Home range studies

Both raster and vector systems easily calculate, display and overlay home ranges. Arc View includes a module with various home range estimation methods, including minimum convex polygon and kernel estimate techniques (Hearn, unpubl.). Alternatively, home range packages such as Calhome can be used to calculate home range size, with GIS used to display ranges, calculate overlap and generate density maps (Rachlow et al., 1999).

4. Estimating population size and distribution

In large areas or areas of thick bush, such as Selous Game Reserve in Tanzania, it may not be possible to know the precise population size and distribution of rhinos. By measuring the density of sightings or other signs in sample areas (Leader-Williams, 1985), and relating this to habitat features, it is possible using GIS to estimate distribution and density across much larger areas, given the appropriate habitat data. Such an approach has been taken for forest elephants using dung counts and habitat data (Barnes et al., 1997).

5. Evaluating patrol effort and efficiency

Using GIS one can easily map the locations of patrol routes and calculate patrol effort in different zones. This can then be related to sighting data, poacher detection data, or data on population decline or recovery in each zone, so as to evaluate the performance or success of law enforcement (Leader-Williams et al., 1990). If habitat data are included one could examine how patrol efficiency varies with different habitat variables, and so more effectively design patrol strategies in heterogeneous landscapes.

6. Modelling population expansion

Once habitat suitability has been established in an area occupied by rhinos, using GIS and statistical analysis, it is possible to predict how and where the population will expand into neighbouring areas. This may be useful in areas where a small population exists in part of the area but which is expected to expand into other parts of the area. Equally, the analysis may show that population expansion is unlikely and that carrying capacity is already reached.

7. Evaluating potential translocation sites

Translocation is a common tool in black and white rhino management, given the need for more and larger populations to buffer against poaching and stochastic or genetic factors. Potential sites need to be assessed as to their suitability for rhinos and the likely population size that they could support. GIS offers a simple means to generate prediction models of the likely distribution and density of rhinos within a new area. These could be based on resource surveys or habitat maps of the area and habitat suitability models from similar sites, or on simple area calculations based on known male home range size and topographic data.

8. Predicting the effects of habitat change and management actions

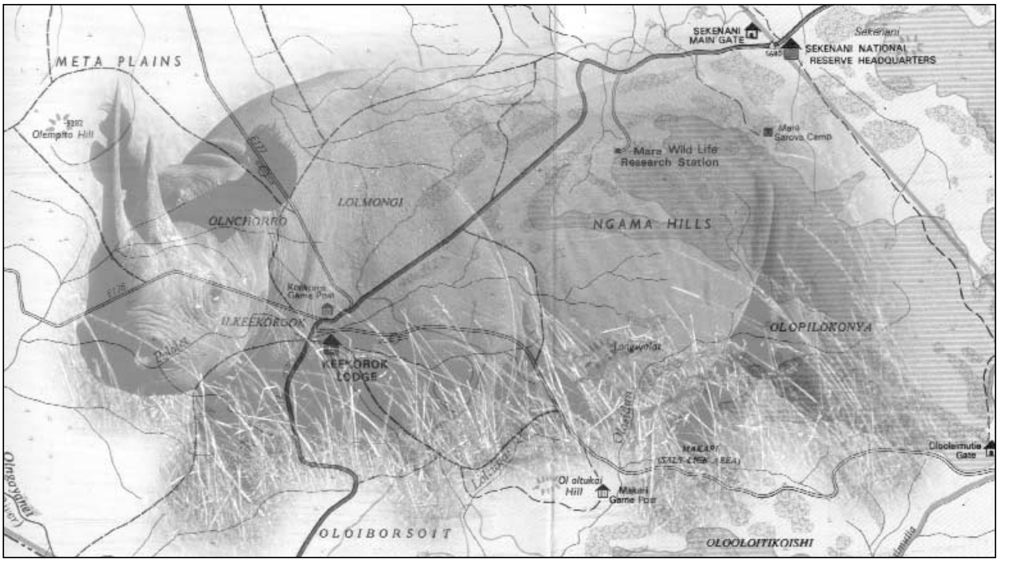
Where temporal data on habitat and rhino distribution are available, it is possible to examine how rhino use of an area has changed with changing habitat or human intervention. Factors such as fire, woodland decline, browse competitor density or tourism development may all have changed the value of an area for rhinos, and this may be reflected in changing use patterns. From these relationships, which can be easily examined using GIS, it may be possible to determine how management intervention could benefit rhinos by increasing carrying capacity.

These are a few ways that GIS could be applied to rhino management. My own study of the black rhino population in the Masai Mara National Reserve in Kenya is using GIS in many of the ways described above. The Mara is a relatively large area that used to support a widely distributed black rhino population of over 100 individuals (Mukinya, 1973). At the current time the population is much smaller and more reduced in its distribution (Morgan-Davies, 1996, Walpole and Bett, 1999). Equally, over the past 30 years there have been changes in habitat and human presence within the Mara that may have reduced the capacity of the area for rhinos.

My study is using GIS to conduct spatial and temporal analyses of factors affecting rhino distribution and density, alongside traditional resource availability and utilization surveys, to assess how carrying capacity in the Mara has changed and what implications this has for the recovery and expansion of the population. The study is ongoing and the results will hopefully be presented in future issues of *Pachyderm.*

OUTLOOK

GIS is a powerful tool for creating maps, making measurements, examining spatial relationships, and undertaking predictive modelling. As such it can greatly assist decision-making by wildlife managers. It has been used in a variety of ways for wildlife management and conservation, and has the potential to benefit rhino conservation by providing ways of presenting and analyzing data, estimating population size and distribution, modelling population performance, assessing the value of potential ranges and analyzing or



predicting the effects of management activities and law enforcement. To date, this potential has not been fully exploited.

Establishing a GIS is within reach of many organizations involved with rhino conservation, given the relatively low cost and high accessibility of personal computers, GIS software and satellite imagery. Data collection, for input into a GIS, could be easily facilitated by rangers equipped with a simple GPS and either a notebook or data capture unit (Liebenberg et al., 1999). Equally, GPS collars provide data downloaded directly into the computer (Douglas-Hamilton, 1998).

There is a need for initial training in the use of GIS and statistical packages for personnel, and there are considerations of data resolution and various error sources to be borne in mind when using GIS (Burrough and McDonnell, 1998). It is, however, undoubtedly a useful tool that will become increasingly widespread as costs decrease further and local skills develop.

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