Working Group Discussion Three*
Elephant - Habitat Working Group

African Elephant Specialist Group Meeting, 17-22 November 1992. Victoria Fails, Zimbabwe

Dr. Russell Taylor chaired the elephant-habitat working group, consisting of about a dozen persons, through several hours of discussions and review over a two-day period, which he describes below.

TERMS OF REFERENCE

GOALS:

To address the current methods of monitoring the impact of elephants on habitat. Evaluate the theoretical models traditionally employed to elephant-habitat research and management in Africa (eg. climax, multiple stable and equilibrium). Question the impact of elephants on habitats, biodiversity and local economies and how these effects can be rigorously studied.

FOCAL TOPICS FOR DISCUSSION:

- Identify recent or on-going studies that have looked into these questions. Cite countries, habitat types and individual investigators.

  Assess whether the concept of "carrying capacity" is still useful. Is there another paradigm that better describes the relationship between elephant populations and their habitats?

- Discuss the impact of elephants on habitats and what bearing this has on biodiversity. both positive and negative.

- Critically assess methods used to measure habitat characteristics and biodiversity and subsequent changes in either or both.

- Review techniques that have been shown to be the most effective for the study of elephant-habitat interactions.

  These may include:

  i. feeding behaviour studies (direct and indirect)
  ii. bioenergetics
  iii. movements in relation to habitat types
  iv. exclosure plots
  v. longterm vegetation monitoring
  vi. modelling
  vii. combinations of the above tools

- Define techniques for measuring the impacts of elephants on biodiversity. Critically assess the indicators that could be used. For example, changes in:

  i. species composition, abundance and distribution
  ii. biomass and productivity
  iii. physical structure of vegetation communities
  iv. plant community structure
  v. animal community structure
  vi. other quantifiable indicators

- Outline ways to measure seasonal variation in the impacts on both habitats/biodiversity.

- Develop meaningful ways of evaluating the economic cost of elephant-habitat interactions outside protected areas.

- Other topics that are considered relevant to the discussion.

DISCUSSION SUMMARY

The response of the working group is presented under the following headings:

* *Working Group Discussions One and Two are described in Pachyderm No. 16.*

1. Elephants and biodiversity

2. Conceptual models for elephant-habitat relationships

3. Management of elephants in protected areas

4. Special problems of elephant management outside protected areas

5. Monitoring elephant impact

6. Summary

7. References

1. ELEPHANTS AND BIODIVERSITY

One of the most widely quoted definitions of biodiversity is that of McNeely et *al*. (1990): "It is an umbrella term for the degree of nature's variety, including both the number and frequency of ecosystems, species, or genes in a given assemblage".

In examining biodiversity, the group noted that **in** general human influence poses the most fundamen-tal threat to change, manifested by ecosystem transformation or habitat modification, in which elephnts may play both an indirect and/or direct role. For sub-Saharan Africa, threats include population pressure, food production methods, foreign debt servicing, commercial land-use practices, over-harvesting, unviable populations of species, climatic change and alien species invasions (Stuart & Adams 1990). In the context of elephants and land use, elephants are probably a manifestation - rather than a fundamental cause - of change.

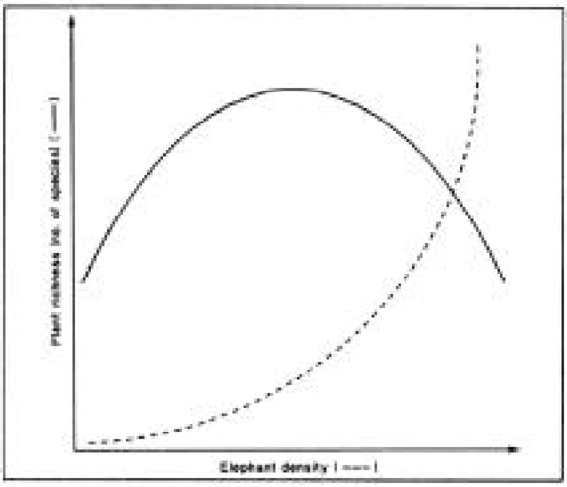
Whilst it was felt that protected areas could be managed for both elephants and biodiversity, and in fact that they need to be, the group noted that elephants can cause a diminishment in biodiversity as their numbers increase. In this regard, unique habitat types and/or areas of endemism may well have to be protected from elephants. Diversity may be increased, however, at lower elephant densities through the opening up of new habitats. Western's (1989) data for Amboseli provide a useful empirical model from which to begin an examination of the impact of elephants on biodiversity (Figure 1). Waithaka (1993) provides similar evidence. The focus in these studies, however, has been primarily the impact of elephants on plant or habitat dynamics.

The group suggested that other useful indicators which could be used to measure change in biodiversity include birds, as well as other vertebrate and invertebrate fauna, in terms of both species richness and abundance.

Of particular importance, noted the group, is the threshold at which irreversible change occurs. In most instances neither the threshold is known nor whether the change is irreversible or not. Many systems with elephants have changed, but in most in-stances little of the change has been quantified. Moreover, change in itself may well be necessary for the maintenance of resilience.

It was generally agreed that elephant-habitat interactions are complex and poorly understood, both in the long and short term, and that establishing cause and effect relationships is therefore inherently difficult.

Figure 1. The relationship between plant richness (numbers of plant species) and elephant density. Redrawn from Western (1989).



2. CONCEPTUAL MODELS FOR ELEPHANT HABITAT RELATIONSHIPS

The group agreed that models can improve understanding of both past and continuing relationships between plants and animals, and of natural processes of population regulation. Models can be used to describe, explore and refine interactive ecological processes, such as between elephants and their habitats, using actual measurements and real data when these become available. In addressing management questions, models can help to tell us what information to collect. Such information can then be used to improve or modify management inputs.

The group extensively reviewed the models that have been proposed to date and which attempt to explain some of these relationships (see also Lindsay, 1993). They were described as:

2.1The successional/climax or Clementsian model

Although this model is the traditional and most common range management paradigm, it is coming under increasing scrutiny as being inappropriate to explain what we see in practice and understand in theory (Westoby et *al.,* 1989). Implicit in this model is the carrying capacity concept and an underlying economic or production basis. It may have relevance in range-livestock systems but not in ecosystems managed for non-economic incentives. Rarely is this distinction explicitly recognised (Caughley 1979, Caughley & Walker 1983. Bell 1985, Behnke & Scoones 1991). This has led to confusion over the use of the carrying capacity concept, which has no objective biological criteria for its specification.

Carrying capacity may be any one of a number of points along a plant-animal isocline (Figure 2) and should be determined by the management objectives of the system under consideration. Some members of the working group felt that the term “carrying capacity” had become somewhat redundant and a more appropriate term might be “preferred management density” which is dependent on the choice of management options available to a manager. Thus management for high animal density implies a lower plant density and vice versa. It was recognised that the relationships depicted in Figure 2 are simplified and do not necessarily predict real plant-animal interactions. Nevertheless, Figure 2 does help to clarify carrying capacity and management by objective.

2.2 Equilibrial and non-equilibrial systems

The successional model assumes a stable or equilibrial system which Figure 2 also depicts. Here, herbivore numbers are controlled through forage availability and vice versa, so that through negative feedback of internal biotic controls a stable equilibrium between animal and plant populations is eventually achieved. A major assumption of equilibrial models is that abiotic or physical controls such as rainfall (which influences plant growth), are relatively constant and unimportant compared to the internal biotic feedbacks of the plant-animal interaction. However, where stochastic or variable abiotic conditions are dominant, the systems tend to be non-equilibrial because the stronger external controls override the internal feedback mechanisms of the plant-animal interaction (Behnke & Scoones 1991).

Figure 2. The plant-animal density isocline and its relationship to carrying capacity or preferred management density.

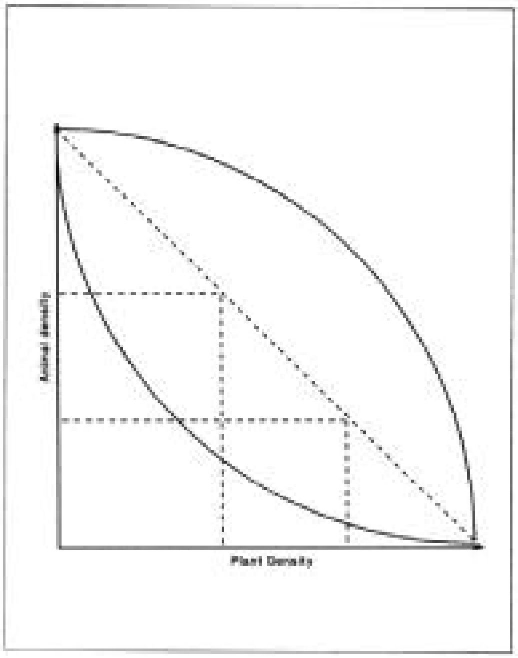
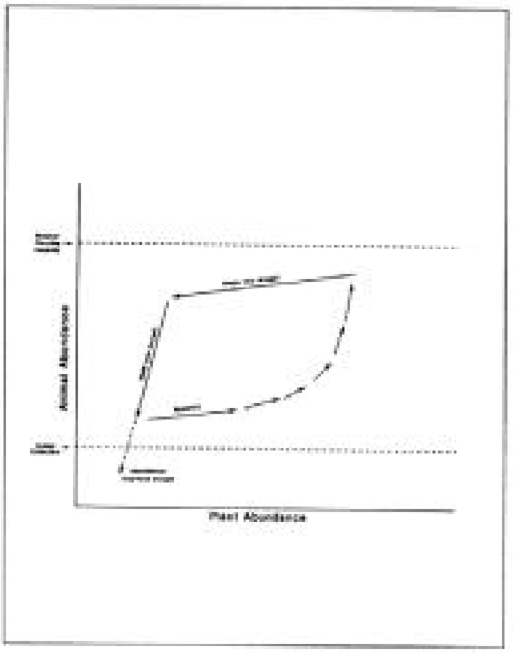


Figure 3. Plant-animal interactions under the influence of frequent drought in northern Kenya. Redrawn from Ellis and Swift (1988).



Such a non-equilibrial system is described by Ellis and Swift (1988) for plant-livestock interactions under conditions of frequent drought in Turkana, northern Kenya (Figure 3). In this system, plant and animal populations both increase under favourable rainfall conditions and contract in times of drought. Low rainfall, rather than too many animals *per* se, limits both food and animals.

2.3 Stable limit cycles

Caughley (1976) suggested that there was no attainable equilibrium between elephants and woodlands. Instead, he proposed - for the Luangwa Valley, Zambia - a stable limit cycle in which elephants increase while reducing woodland, and then decline to a density sufficiently low to allow woodland regeneration. This in turn triggers an increase of elephants and the cycle repeats itself. He argued that man can impose only an artificial equilibrium on the system such that trees and elephants are trapped at the low density phase of the cycle. Such a system, however, is essentially equilibrial but has such strong internal feedbacks that it departs from equilibrium and, when accompanied by time lags, results in a stable limit cycle (Ellis & Swift 1988).

Like Caughley's (1979) equilibrial carrying capacity model in Figure 2, the stable limit cycle model does not take into account the stochasticity of strong external abiotic controls. In addition, nonequilibrial systems tend to be spatially extensive and external factors (e.g. human influences) may be critical to their dynamics.

2.4 State and transition models

Westoby et *al.* (1989) argue that event-driven or episodic variables such as rainfall or fire, which are not constant in their effect, may change range-land systems in an irreversible way which is inconsistent with the succession model. This may be more so for arid and semi-arid regions. The state and transition model is proposed as an alternative to the range succession paradigm for nonequilibrial systems.

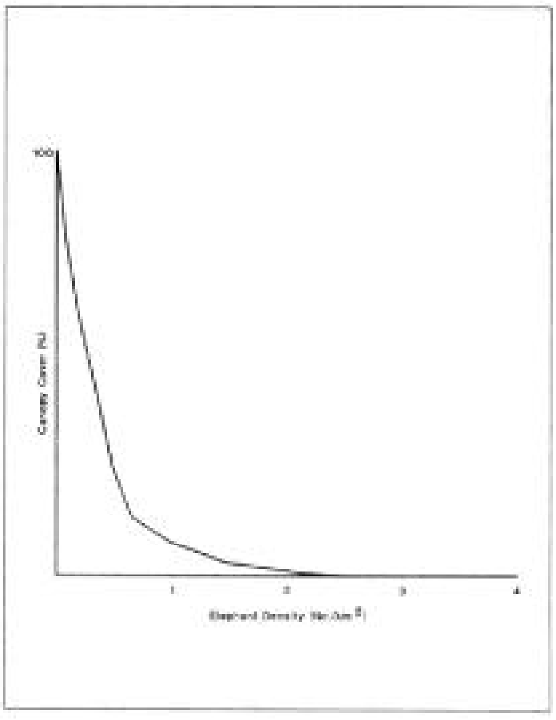
In this model, a system is described by a set of discrete vegetation states with a set of transitions between them. Transitions are triggered by natural events, management inputs or combinations of these. The probabilities of such occurrences are estimated through adaptive or experimental and opportunistic research. This model is proposed not so much as an advance on current theoretical models, but because it organises information needed for management. Hence management, rather than theoretical criteria, is used in recognising states under given situations.

2.5 Multiple stable states

Multiple stable states in ecosystems have been proposed theoretically. Boundaries will exist between states when the system, once moved into another state, does not return to its original state. The factor responsible for change returns to its original value and another factor holds the system in the new state.

These predictions have been examined for the Serengeti-Mara woodlands by Dublin et *al.* (1990). Elephant-woodland and fire-woodland interactions were modelled to test the hypothesis that elephants and fire, respectively, caused woodland decline and that the same two factors prevented its recovery. The conclusion was that fire alone, but not elephants alone, could change woodland to grassland but that once the grassland was formed, elephants alone would maintain the grassland state. When fire acted with elephants, this produced the highest rate of woodland loss, which most closely matched that which was measured off photographs. Elephants and fire together are probably preventing woodland recovery at present.

Figure 4. Tree-elephant equilibrium for Acacia woodlands in Zimbabwe. Redrawn from Craig (in press, a)



2.6Tree-elephant models

Specific tree-elephant models which hold one or the other factor constant and then measure the consequences have been developed by Barnes (1983) and more recently by Craig (in press, a). The influence of fire as an additional factor has been included in the models of Norton-Griffiths (1979) and Pellew (1983). Craig (in press, a) clearly demonstrates that for Zimbabwean woodlands, canopy cover can only exceed 50% at elephant densities below 0.2 el-ephants/km^2 (Figure 4). His model is essentially equilibrial, however, and makes use of a space transition matrix which assumes a stable age distribution for woodland.

2.7Dynamic system models

Most system models fail to account reliably for the dynamics of both trees and elephants and the interaction between them, and other stochastic variables, without the use of detailed measurements and/or unrealistic assumptions. The benefits from most conventional system models are usually lost in the uncertainty and complexity of the exercise.

Rule-based models (Starfield & Bleloch, 1986) are simple and make use of as much (or as little) information as is available. The artificial intelligence (AI) construct of a frame to describe ecosystem processes under different states or regions of operation allows for dynamic simulation capabilities while retaining the conceptual simplicity of a state and transition model (Starfield et *al.*, in press).

By partitioning the temporal dynamics of the system, only one simple model is operational at any time. Further refinements also provide for spatial heterogeneity to be taken into account, so that movement in and out of interacting regions can also be modelled. This approach is being explored presently in the management of elephants, fire and miombo woodlands in Zimbabwe (Starfield et *al.*, in press).

While perturbations and episodic events are accepted as key components of ecosystem processes, an often neglected factor is the scale, both spatial and temporal, at which these processes may have operated and the constraints at which they operate today. Models should also be applied to interactions with people and their economies. For example, hunting, poaching and human population expansion and contraction in relation to land use, in the past and now, have often been ignored as factors in elephant regulation (Hanks 1979, Owen-Smith 1983, Craig, in press, b).

3. MANAGEMENT OF ELEPHANTS IN PROTECTED AREAS

The working group recognised that managers are often required to manage protected areas which support elephants at a scale much smaller than before. Consequently, for many areas, implicit in their management is an underlying acceptance of the successional/climax mode! especially to minimise the risk of irreversible change. Such an approach to management often reflects caution without a real appreciation of the probability of risk involved.

Adaptive management means that simple system models of the underlying interactions can be built and tested in the day-to-day management of protected areas. Predicted outcomes can be measured through monitoring and evaluation, with feedback systems to allow for corrective action when and where necessary.

There was clear and strong consensus that management must be goal-orientated with goals and objectives flowing from an overall wildlife policy and its enabling legislation. It was recognised that for many wildlife agencies this had yet to be achieved.

It was pointed out that management by objective enhances flexibility and encourages adaptive approaches, especially when supported by rigorous monitoring and evaluation.

The group agreed that management goals will differ between management authorities, but the use of models could allow managers to begin to formulate their goals and objectives. For example, given the considerable confusion and lack of clarity that arise over the use of the term carrying capacity, managers could decide on a density of both plants and animals which reflects a preferred management option, derived from policy and objectives (Figure 2). Figure 4 (Craig, in press, a) provides a quantitative and objective basis for such decisions and gives managers a more realistic view of the problems they face. This approach allows levels of habitat use to be pre-determined which are permissible in terms of stated goals.

4. SPECIAL PROBLEMS OF ELEPHANT MANAGEMENT OUTSIDE PROTECTED AREAS

It was recognised by the group that many elephant populations, habitats, plant and animal communities which exist outside protected areas deserve attention. Specific problems include the impact of el-ephants upon habitats, the loss of habitat or its fragmentation due to human influences, and the growing conflict between elephants, people and other forms of land use such as agriculture and agro-forestry. For a number of countries elephant range extends beyond the boundaries of formally protected areas and significant numbers of elephants occur outside these areas (Thouless 1991, Taylor *et al.,* 1992). Consequently the movements of elephants have become restricted and/or their traditional range has undergone shifts, both in time and space.

Where this has lead to conflict between people and elephants there is now an urgent need either to reduce the level of conflict or to increase levels of human tolerance, or both. The group discussed the pros and cons of various measures to reduce conflict, which include control of elephants through shooting or harassment (both of which were felt to be of dubious benefit) and the use of electrified game fences. The latter is currently being attempted in various localities with different measures of success. Given the present state of technology, well-applied electric fences can act as a powerful deterrent to elephant entry and trespass (Hoare 1992). An often neglected aspect of electric fences is their cost-effectiveness, and to this end, economic cost-benefit analyses are essential prerequisites.

The group heard about other methods of deterrence presently being explored, which include the use of chemical aerosols (Osborn 1992). Osborn is also investigating the ecology of crop-raiding elephants, a hitherto neglected aspect of human-elephant conflict in Africa but one which has received considerable attention in Asia (Sukumar 1990).

Community-based wildlife conservation and management programmes are currently underway in a number of countries and include Admade in Zambia, Campfire in Zimbabwe, the auxiliary game guard system in Namibia, multiple-use areas in Bophutatswana as well as a number of initiatives in South Africa, notably Londolozi where private enterprise is directly and actively participating with local communities in shared financial and economic ventures.

Given the growing complexity of problems associated with elephants outside protected areas, as well as the potential for solutions which link economic incentives to elephant conservation, it was recommended that a working group be set up specifically to examine these multifaceted issues.

5. MONITORING ELEPHANT IMPACT

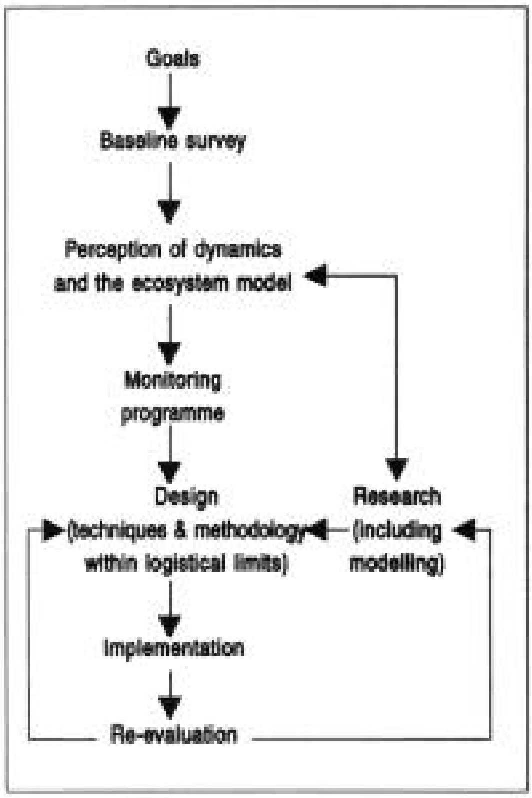
The group agreed that monitoring is of prime importance for providing information to evaluate management and to improve our understanding of ecosystems with elephants.

A monitoring system cannot be implemented in one step. A logical framework for developing such a system is shown in Figure 5 (Macdonald & Grimsdell, 1983) where it can be seen that the intended monitoring system must be linked, from the outset, to clear management goals.

Essentially, there are three approaches to management, namely:

- **i.** minimal management,
- **ii.** management for ecological objectives and
- iii. management for economic objectives.

Figure 5. A possible framework for the development of a monitoring system. Redrawn from MacDonald & Grimsdell (1983).



Monitoring will differ for each of these strategies. The role of a conceptual or ecosystem model helps in the design of the monitoring system and programme.

The group noted that a monitoring programme aims to measure the rate and direction of change in an ecosystem. An essential requirement of a monitoring technique is to provide the minimum data set needed to give the required information to detect such change. A further important component is time. Inevitably, much monitoring is longterm and repetitive - hence the importance of a model which identifies key variables and processes which may require monitoring and/or further research to ensure that costly omissions or mistakes are avoided.

The group discussed the components which must be considered during the initial design stages of the programme. Monitoring should be sufficiently straightforward and feasible to ensure continuity over time, and personnel must be adequately trained.

Several important variables were listed which need to be considered in relation to elephants, biodiversity and human activities. For each variable to be monitored in an ecosystem, it is necessary to consider the frequency, scale, replication, accuracy and precision of measurement needed to provide the desired level of resolution. Likewise, ecosystem components requiring monitoring will depend on the objectives of the monitoring system.

A discussion on the use of permanent plots, transects, fixed point photo-panoramas and aerial photography for measuring elephant impact followed the above points. Exclosures were considered useful for assessing site potential and likely recovery rates. Ways in which animals could be monitored were listed as simple wildlife reporting systems, ground counts, aerial counts and other indices of abundance. The group recognised that any technique would have to be area or component specific.

Macdonald and Grimsdell (1983) have compiled detailed tables and lists specifying those ecosystem components that require monitoring, and the levels at which they should be monitored, for arid, semi-arid and sub-humid bioclimatic zones. It was noted that these tables provide an extremely useful starting point for any intended monitoring system.

The working group also attempted to clarify the links between research and monitoring. Research is conducted, by way of testing hypotheses, to increase understanding of the ecological components and processes of ecosystems, whereas monitoring is the means to measure the direction and rate of these processes. Both research and monitoring are interdependent and should contribute to the same end. Although it may or may not be directly relevant to management objectives in the short term, research is essential in the long term for testing the assumptions on which most of our management is based. Monitoring, however, is directly related to management objectives.

In this regard, the organization and dissemination of information from a monitoring system, and its intended use, is of great importance. If the data collected are not effectively fed back to managers, then the investment in the monitoring programme is wasted. Thus information storage, analysis, interpretation and feedback, as well as regular reevaluation, are essential components of the system.

6. SUMMARY

Both within and outside protected areas, managers are required to take decisions in the light of presently inadequate knowledge or information. This continues to be so especially in the case of elephants, their habitats and the human populations around or amongst them - and the problems that manifest themselves as a result of these interactions. In the wide-ranging discussions outlined above, the group found the following schematic outline (Figure 6) was useful in bringing together these seemingly disparate components. This approach to the management of elephants and their habitats endeavours to provide linkages between policy, management, monitoring and research and brings some clarity to often misunderstood and confused ideas about the conservation of elephants.

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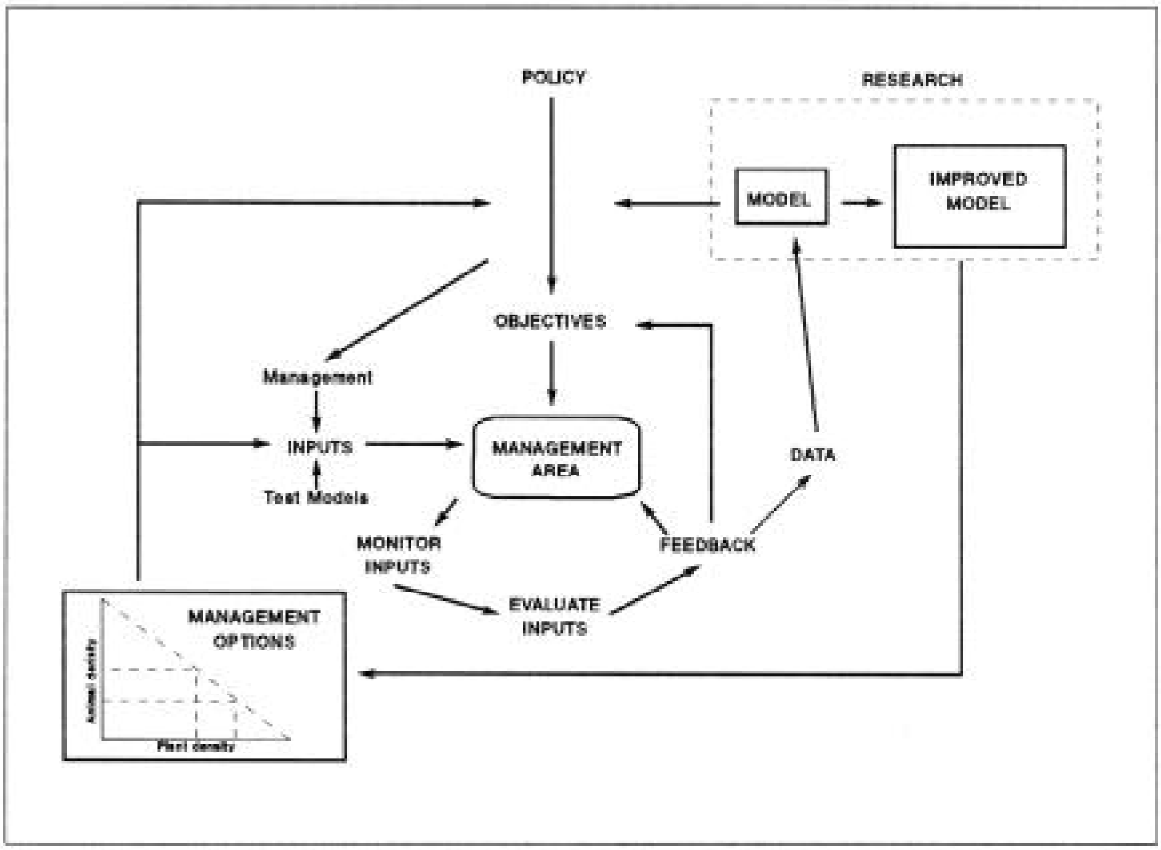
Figure 6. A suggested framework for the development of a management system in wildlife conservation areas. Such an approach may apply equally to protected or non-protected areas.



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