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Guidelines for the management of large mammals in African conservation areas

The product of an international workshop
held at Olifants Camp, Kruger National Park, South Africa

A report of the Committee for Nature Conservation Research
National Programme for Environmental Sciences

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The editor specifically wishes to thank those who took part in the workshop, all of whom are in fact joint authors of these guidelines (see page xvi). Each chapter was intended to be compiled by an appointed team under the direction of a pair of team leaders. But things did not work out that way. The participants worked in several groups which changed daily according to the interests of each individual. Special thanks are due to those more active members who contributed substantial authorship to several chapters. Their changes, and even those of team leadership, were often hard to follow. As a result, a faithful reflection of the real joint authorship of each chapter is not possible. All sections of the initial draft were submitted to plenary review sessions of the workshop, so the document is truly a team effort. However, the editor accepts responsibility for all inconsistencies, errors and modifications that may be found in the final publication.

The success of the workshop was in no small measure due to the excellent secretariat facilities provided by Fifi Bierman, Tisha Greyling, Polly Newsholme, Margaret Orton and Ruth Viljoen, and to Brian Huntley's ability in keeping the often disparate group, both on course and on time.

"The world is not simple and things are not always as they seem. In many instances the obvious management response to a problem is not appropriate, it may even produce an effect directly opposite to that intended. This reflects the inherent difficulty in establishing cause and effect relationships in complex poorly understood systems. Change in itself is not a bad thing, it is in fact a requirement for the maintenance of high resilience. In many cases culling is by no means either the conservative or the safe option. The more one tries to prevent change, the more management effort will be needed in the future."

G Caughley and B H Walker

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	(iii)
PREFACE	(vi)
SYNOPSIS	(viii)
Chapter 1	
GOALS FOR PROTECTED AREAS - *management objectives for nature conservation*	1
Chapter 2	
WORKING WITH ECOLOGICAL IDEAS - *ecological concepts*	13
Chapter 3	
WILDLIFE AND SOCIETY - *socio-economic and political considerations*	35
Chapter 4	
DECIDING WHAT TO DO AND HOW TO DO IT - *planning, selecting and implementing field management options*	51
Chapter 5	
WHAT CAUSES CHANGE? - GETTING AT THE FACTS - *the role of ecological monitoring*	77
REFERENCES	(xiii)
LIST OF PARTICIPANTS	(xvii)
TITLES IN THIS SERIES	(xx)

PREFACE

International concern about the practice of cropping or culling wild animals, especially those species singled out for protection, has grown rapidly in the last decade. As a result, in September 1980, a workshop entitled "Problems in Management of Locally Abundant Wild Mammals", was held at Cape Cod, Massachusetts. It took the form of an investigation into the theoretical and scientific bases for justifying the deliberate killing of overabundant mammals.

The published proceedings of that workshop (Jewell et al 1981) serve to clarify a great deal of fuzzy thinking on the part of wildlife scientists but, because of the limited bounds within which overabundance was considered, they do not provide comprehensive answers to several of the all-embracing problems that were tackled. What emerged from the workshop was that the problems of conserving protected species are not matters for scientists alone. Conservation is a multi-disciplinary activity and it's management decisions must therefore be similarly widely based.

In common parlance "management" is the antithesis of "wilderness" and for some of us, wildlife management is a self contradictory idea. Conservation areas are scattered throughout the lands that man has settled and, whether managed or wild, they cannot escape his influence. In the very act of caring for wild lands man imposes some interference. Making only a few roads into the wilderness and declaring that people must not leave them, is management. Putting a fence round a wildlife area and decreeing that no one may enter, would be a profoundly far reaching act of management.

There is no field of conservation in which this modification of the wilderness idea is more acutely felt than in the management of large mammals. Large mammals are mobile, they disperse from sanctuaries and harass farmers. Here, management by intervention is imperative. If confined and numerous they are likely to accelerate change in the distribution and diversity of other animals and plants. This change is usually in a negative direction, towards depletion and simplification of biota, and consequently drier and less productive conditions. Should man intervene?

These problems, which were tackled from the limited point of view of overabundance at Cape Cod, were set in a much broader context at the South African meeting. This conference took the form of a formal, two day symposium followed by a five day workshop at Olifants Camp, for forty of the symposium participants. The symposium proceedings (Owen-Smith in prep) provided the background to the workshop discussions. A significant feature of these proceedings was the development of ideas around the two extremes of management. The first is that of non-intervention, with emphasis on ecological baseline areas or control zones, set aside for the conservation of ecological processes. The second, involves active and often continuous intervention, with emphasis on the conservation of genetic material and species diversity.

These guidelines accept the ambiguities inherent in both the scientific theory and the practical realities of conservation in Africa. They are published here to help conservation decision makers and managers, together

with their scientific advisers, reach a logical concensus as to the choice of management options in cases of apparent overabundance. It should not be surprising that the resulting discussions grew into a wide ranging treatment of management in its broadest context. The management of conservation areas, like ecology, is an activity that does not readily submit to the confines of strict definitions - it is not a limited activity. Nevertheless this publication has limitations and makes no claims to being comprehensive. The editor welcomes comment, correction and constructive criticism and invites appropriate correspondence, with a view to producing a revised edition in two to three years time. In this regard no attempt is made to deal with topics such as selection of areas for nature conservation (Siegfried and Davies 1982), park planning, education and interpretive services, training and recreation. These vital aspects of protected area management deserve separate treatment in detail.

SYNOPSIS

Now culling was up for debate
At a camp near Olifants gate
With thoughts esoteric
They drove us hysteric
*While the mammals awaited their fate**

RP

The principal aim of this book is to provide wildlife managers in Africa with a set of guidelines that will aid their decision making process, especially where questions relating to the overabundance of large mammals are concerned. However, in keeping with the complex causes and effects involved in cases of overabundance, these management guidelines range widely over a full spectrum of management activities.

Chapter 1 addresses the basic need for clearly stated goals before any management action is initiated. Goals should be set within a framework of priorities, with international, national, regional and local levels of relevance. The essential tenets of conservation - the right of all organisms to exist, and the need to preserve living resources and processes for the continued benefit of mankind - are seen as the central theme within which a wide range of subsidiary objectives can be met through the establishment and management of conservation areas. These alternative objectives, and the varied categories of conservation area to which they may apply, are described. The need for a diversity of conservation systems is emphasised as a basic prerequisite to achieving the goals of conservation.

Goals set for specific protected areas should be periodically reviewed - they should not be regarded as static or sacrosanct policy statements. Participation by a full representation of interested parties should be encouraged in the development of conservation strategies from national to local levels.

The ecological basis of wildland management is considered in Chapter 2. The discussion is focused principally on the savanna systems of tropical Africa, but the concepts undoubtedly have wider application. The great diversity and complexity of ecosystems, their components and processes, is recognized. In particular the need to understand ecological processes,

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*The elegant verses adorning these pages, spring from the pens of competitive sages, who, when persuaded to spend an extended weekend (writing limericks) produced guidelines instead, without wages. - ed.

rather than their individual components, is highlighted. Contrary to popular belief, the outcome of ecological processes is often counter-intuitive; things are often not what they seem to be. The need for humility in taking strong management decisions is an obvious consequence of this insight.

Various categories of perceived and real carrying capacity and overabundance are described - the optimum carrying capacity for any community is not a constant. Furthermore, episodic events, including eruptions of herbivore populations and non-cyclic climatic extremes, are seen to be vital components in the dynamics of natural ecosystems. Wide deviations from the normal, both in respect of biotic as well as abiotic components of ecosystems, are no longer seen as symptoms of ecological collapse. Increasingly, these extremes and stresses are being viewed as the means by which short-term resilience is developed, contributing to the achievement of long-term ecological stability.

The chapter describes basic features of the structure and functioning of tropical savanna systems - the role of fire, soil, water, game movements, plant-animal interactions and climatic factors. It emphasizes certain features of these ecosystems, such as the significance and sensitivity of ecotones and the importance of mosaic patterns in apparently homogeneous vegetation. The need to preserve variety, both within and between protected areas, has not been adequately recognized in the development of national or regional conservation strategies. Measures to conserve specific communities and varieties of biota outside the traditional conservation areas - in farmlands and managed forest areas - need consideration. Conversely, the mixing of ecotypes as a consequence of endeavours to re-introduce species to areas in which they have become extinct, has serious genetic implications.

The competition for resources between local people and conservation areas is described, in Chapter 3, by way of a curvilinear relationship leading almost inevitably to conflict. Where conservation areas have been developed in the absence of active consultation with both local and distant, but affected, populations, they have rapidly become islands in a sea of discontent. Attempts to ameliorate these situations by offering local populations a share in consumptive benefits, such as those produced by culling operations, are seen as of short-term value. In the long term they create a demand which can never be sustained and their benefits reach only an insignificant proportion of the people.

A new approach to resolving the growing conflict must be found. Socio-economic surveys are needed to develop an understanding of perceptions and responses of people to island reserves. Wildland managers need to extend their interpretive services outside the boundaries of parks. Agricultural extension services and the active development of multiple land use systems around the periphery of conservation areas, is seen as a wiser course to the alternative of multiple use within reserves. Attempts to expand the consumptive use of resources from reserves, through hunting, culling or other extractive practices, are seen to be in conflict

with some of the long-term goals of conservation. However, where there are good prospects for long-term control and an effective marketing system, then economic goals may well be justified in practice. But such materialistic values should be secondary to the development of cultural and aesthetic values, which are seen as more durable in the long run. Fundamental to this course of action is the need to develop local tourist use, rather than foreign use of reserves. Too great an emphasis has been placed on the contribution tourism makes to foreign exchange. This may develop a real but counterproductive impression that, in Africa, conservation areas are maintained for the use of foreign visitors, with few benefits reaching the local population who may have experienced nothing but negative consequences from the establishment of a reserve.

Caughley flew in from Australia
His face lit up like a dahlia
"Don't cull them," he said
"Lest they die off instead,
In a frenzy of normal behaviour"

AK

The decision-making process is analysed in detail in Chapter 4. Two basic concepts are classified from the start. First, there is the distinction between technical decisions and decisions of preference. The former rest primarily on the level of biological understanding of the ecosystem concerned, while the latter falls in the area of politics, socio-economics and personal likes and dislikes. The majority of decisions are taken on a basis of preferential rather than technical considerations. Secondly, there is the frequent but unfortunate conflict between biologists and managers. This is seen to be an artifice. It is concluded that there is no clear division between the provinces of research and management and little is to be gained by trying to emphasize the distinction. In the past, the lack of clarity in these two concepts has led to compromise decisions, often resulting in the acceleration rather than reversal of negative trends.

A series of flow-diagrams and tables provides a generalized framework which decision makers can apply to a wide range of typical wildlife management questions. Examples are cited from experience in east, central and southern Africa, illustrating the consequences of a variety of approaches to the solution of management problems.

The final chapter examines the need for, and approach to, monitoring and research as a means of providing managers with information. Monitoring is not an end in itself. Monitoring must be planned relative to the area's goals. For most reserves there is a need to develop a conceptual model or description of the system, around which the monitoring programme develops. The model's principal use lies in the identification of key ecological

components and processes and the determination of significant time scales. A monitoring system needs regular evaluation, or even re-design, in the light of changing goals and circumstances. While many systems might only include coarse measures of climatic, vegetation and animal variables, a minimum data set is essential for accurate interpretation of cause-and-effect relationships. Logistical limitations often result in monitoring systems becoming sub-critical and ineffective, with the consequence that significant funds are devoted to pointless exercises. The importance of identifying the processes and their rates and direction of change, is obvious. A table at the end of the chapter (Table 5.1) provides specific guidelines as to which ecological features and processes should be monitored under a variety of circumstances. It also indicates the recommended frequency and the levels of accuracy and precision that should apply to each measurement.

A monitoring system which does not permit rapid analysis of results and their subsequent communication to managers in time to influence decisions, is only of academic interest. The increasing need for on-site computer aided systems is therefore obvious, even if it is a goal that will not be easily reached in many African conservation areas. Monitoring activities will not always produce direct answers for management problems. More often they will, or should, pose additional more penetrating questions. This serves to identify future research priorities and, as such, is one of the most useful specific roles of monitoring. It is, in fact, unwise to draw a fine distinction between monitoring and research, just as it is between research and management, or management and decision making. All are integral parts of the management function, which must be skillfully coordinated for the successful running of any conservation area.

I'm so glad I live in a zoo
Where culling is strictly taboo
I don't feel redundant
Nor overabundant
I'm just a g-nother gnu

AS

Chapter 1

GOALS FOR PROTECTED AREAS

Management objectives for nature conservation

Compilation led by
Kenton Miller and Graham Child

INTRODUCTION

WHY CONSERVE?

WHAT ARE GOALS?

WHAT GOALS ARE SUITABLE FOR PROTECTED AREAS?

HOW DO WE SELECT GOALS?

- Conflicting goals
- Global, regional and local goals
- Ranking goals according to priority

HOW SHOULD GOALS BE STATED?

HOW DO GOALS FUNCTION THROUGH TIME?

GOALS - A PERSPECTIVE FOR THE POLICY MAKER

INTRODUCTION

The management of protected areas is not an end in itself: it is the means by which specific ends are achieved.

In order for wildlife managers to achieve their ends or objectives it is necessary first for these to be clearly defined (this chapter) and second that they have an appropriate selection of strategies available to make their achievement both possible and practical (in terms of the concepts and constraints described in Chapters 2 and 3). It is in this context that the term "management" is used in these guidelines. It refers to the biological and administrative strategies that are used to achieve the goals of nature conservation in protected areas (Chapter 4).

"Management by objectives" is a standard procedure for achieving goals in the business world. In the field of conservation, where goals are much more complex than the maximisation of profits, such a disciplined process is even more necessary. In principle the procedure of defining goals is the same at all levels, from those for a large government agency to those for a specific research or development project.

It is important to recognise that the selection of objectives is a matter of choice, guided by science but determined by personal or public preference. In contrast, the measurement of progress towards those objectives (Chapter 5) is entirely a scientific or technical matter described by means of facts and figures.

In African conservation areas a variety of biological management styles have evolved. These are generally related to the availability of financial and trained manpower resources. The management styles in existance comprise a full spectrum of intensities, from totally passive on the one hand to highly active on the other. Passive management involves protection, preservation and a minimum of human intervention in nature, while active management is concerned with enhancement, utilization and overt manipulation of the biological system.

Situations involving "overgrazing", "overabundance" and the possibility of culling provide ideal examples of how management relates to objectives. This handbook uses these situations to explore and, we hope, explain these relationships. This chapter sets out to describe how conservation goals should be defined and re-evaluated, by providing generalised answers to a set of practical key questions.

WHY CONSERVE?

Nature conservation is based on two philosophical principles. The first holds that all organisms, as well as man, have a right to exist. The second holds that living resources should be preserved for the benefit of present and future generations of mankind. These two principles are not necessarily in conflict. The right of all life to exist is central to many philosophies and religions of both eastern and western cultures. The need for living resources to be preserved for the benefit of man has recently been developed into the World Conservation Strategy (WCS) by the International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF). This document, produced through reference to over 800 scientists, administrators and managers world wide, is a most thorough and widely applicable statement on the global role of conservation. It is supported and endorsed by the United Nations agencies, UNEP, UNESCO and FAO and a great many governments throughout the world. Consequently it forms a key philosophical basis for conservation, both in Africa and world wide. It fully describes the wider goals of conservation and outlines strategies for achieving them.

A key message in the WCS is the need to establish and maintain protected areas within which species, communities and ecological processes can be preserved under conditions of minimal human influence. In many areas such protection has led to a great increase in the numbers of certain large mammals and to changes in plant and animal communities. Decision makers and managers have then been faced with the dilemma of either killing the animals they intended to preserve, or of allowing ecological processes of change to proceed unhindered. It is in the context of this particular management problem that this handbook has been prepared.

WHAT ARE GOALS?

It is important to distinguish between the goal and the means by which it may be achieved. Culling elephants for example, may be a means of protecting a particular plant community. The goal in this case is maintenance of a thriving plant community. It may equally well be achieved by putting up a fence or closing an artificial water point.

In the context of conservation it is useful to recognise that goals are set to apply at various levels. Global goals are stated in the following terms in the WCS :

- To maintain essential ecological processes and life support systems
- To preserve genetic diversity
- To ensure the sustainable utilization of species and ecosystems

Local goals, such as those applying to a particular protected area are stated in more specific terms in law, policy documents and management plans. The various levels of goals may be viewed as nested sub-sets of the overall set of conservation goals, from the national level down to that of an individual's function or project. The importance of internal consistency and compatibility of sets and sub-sets of goals cannot be over emphasized (Figure 1.1).

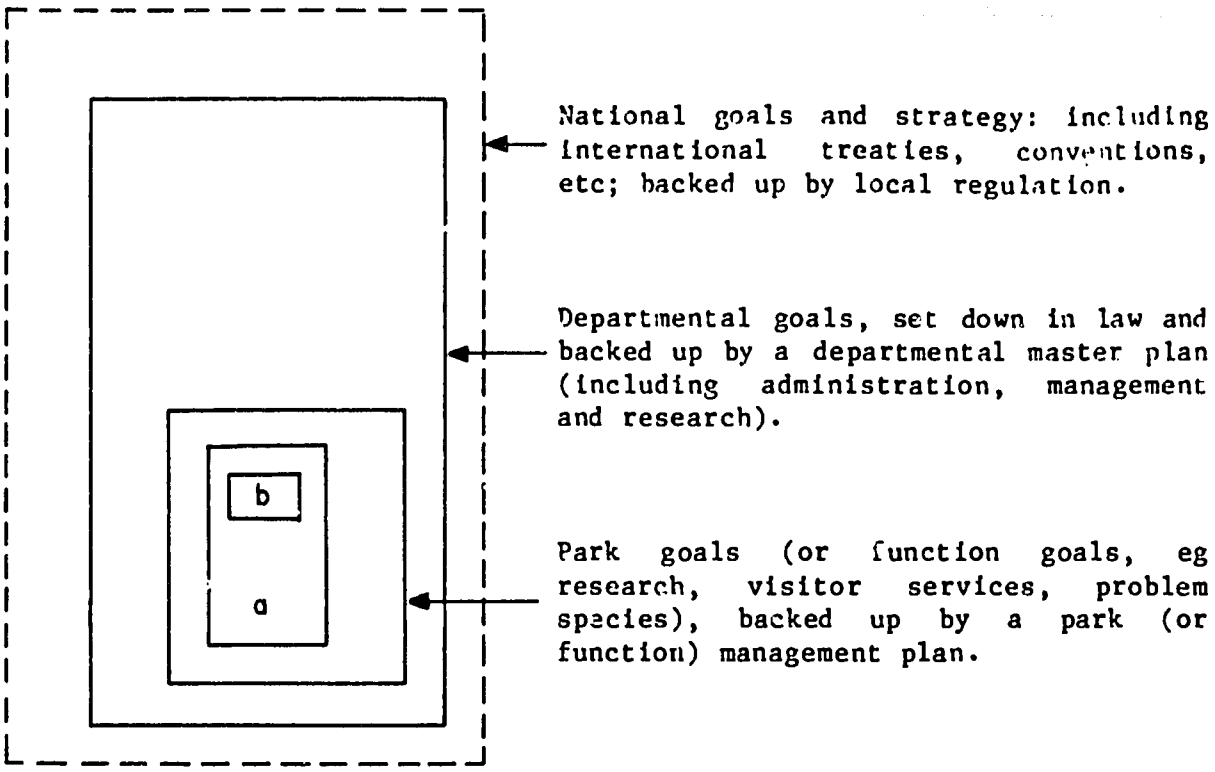

FIGURE 1.1. A hierarchy of conservation goals at three levels. Additional, intermediate levels could be added catering for regional or district interests. More specific goals for sites or zones within a park, or particular projects within a function could be included at a finer scale (a and b). In practice there would be condsiderable overlap between goals.

WHAT GOALS ARE SUITABLE FOR PROTECTED AREAS?

Protected areas such as national parks, wildlife sanctuaries and forest reserves, provide the locations for people to achieve on-site conservation of renewable resources and maintain a part of their natural and cultural heritage. They also serve to protect plants and animals for future crop and livestock improvement and for the potential development of pharmaceutical products. They support recreation and education and provide opportunities to learn how ecosystems operate. In a regional context, protected areas can contribute to rural development and community welfare by safeguarding stream-flow, preventing erosion and providing limited employment. Additional goals may be tailored to specific local needs and moral obligations particularly to subsistence level societies.

Wild land and water areas are selected for protection because their natural resources are valuable for particular purposes. Procedures for identifying and selecting new protected areas for various purposes, are provided in the HABCON workshop publication (Siegfried and Davies 1982). Goals are then set that provide direction for the management of the area selected.

Ideally, general goals for the management of a protected area are chosen as part of the planning process. Several "ideal" goals are suggested, drawn from existing parks around the world:

a. conserve a representative sample of a biological region (province, biome or habitat) in a state relatively unaltered by modern man;

b. maintain areas and features that are essential for ecological processes such as migrations, stream-flow and biological cycles;

c. maintain genetic diversity and avoid the loss of species;

d. provide facilities and opportunities for environmental education, research and monitoring;

e. ensure the production of high quality freshwater with acceptable flow characteristics by means of watershed management;

f. minimise the erosion and transport of soil, especially that which may adversely affect nature conservation and downstream investments in irrigation, fisheries, navigation, transportation, energy production and recreation.

g. maintain and manage fishery and wildlife resources for sustainable production of protein and as the basis for industrial, sport and recreational activities;

h. provide recreation opportunities for local and/or foreign visitors;

i. protect and make available cultural, historic and archeological objects, structures and sites for public visitation, research and education purposes;

j. protect outstanding scenic landscapes for aesthetic and cultural purposes and provide enhanced settings for towns, highways, rivers or cultural and recreation sites;

k. retain a maximum choice of land-use options for the future in respect of a particular area of land or water;

l. support and, when appropriate, integrate economic and social activities in adjacent lands, with the land-use practices of protected areas.

At the local level, these general goals are restated in a more detailed form to relate directly to biological systems, species and sub-species or other specific targets.

HOW DO WE SELECT GOALS?

Conflicting goals

Many of the goals listed above can be attained in a single area but some may conflict. For example, in the Umfolozi Game Reserve, Natal the goals of white rhino preservation, and maintenance of species diversity can be pursued simultaneously. However, adding to these two goals the intent to maintain the reserve in a natural state free from overt management, clearly

leads to conflict. In the case of such conflict, one goal must outweigh the others. Typically it is possible to pursue two or more goals in any area, but where conflicting goals occur, it may be possible to achieve them in different sectors of the protected area through zoning.

Global, regional and local goals

In order to avoid conflict between the different goals of a reserve it is useful to arrange them in an order of dominance. From a conservation point of view a logical hierarchy follows the sequence from global (highest) through regional to local (lowest) importance. The flow diagram (Figure 1.2) illustrates the sequence of decisions in choosing goals. It goes without saying that it should be the target of every conservation agency to work towards a full and balanced array of goals that satisfy the conservation needs of its country and all its people.

To show how this flow diagram can be used, a few examples are given.

- The mountain nyala inhabits an area in Ethiopia; the flow diagram shows the species to be important at the global level (because it is found only in Africa); at the intra-African level (only in Ethiopia); and locally because it is found in only one area.

- The southern white rhino is for the same reason important at the global and intra-African level (South Africa only) but less important at the local level because it occurs locally in several protected areas.

- The wildebeest is important globally as a valuable species and a dominant grazer of African grasslands. It is of less value at the intra-African and local levels for it is found in several countries and many national parks.

However :

- The Serengeti wildebeest migration as a phenomenon or process is important at all levels following the same reasoning as for mountain nyala.

- The nyala in Malawi is of global importance as an African antelope of limited distribution; it has limited intra-African importance because it occurs in protected areas in several countries but the Lengwe population is of national importance as it is the only population occurring in Malawi.

Following the selection of goals on conservation criteria, the manager together with the policy maker must also consider :

- Potential contribution to community welfare. To what extent do the goals contribute positively or negatively to surrounding local communities? How can these contributions be more positive?

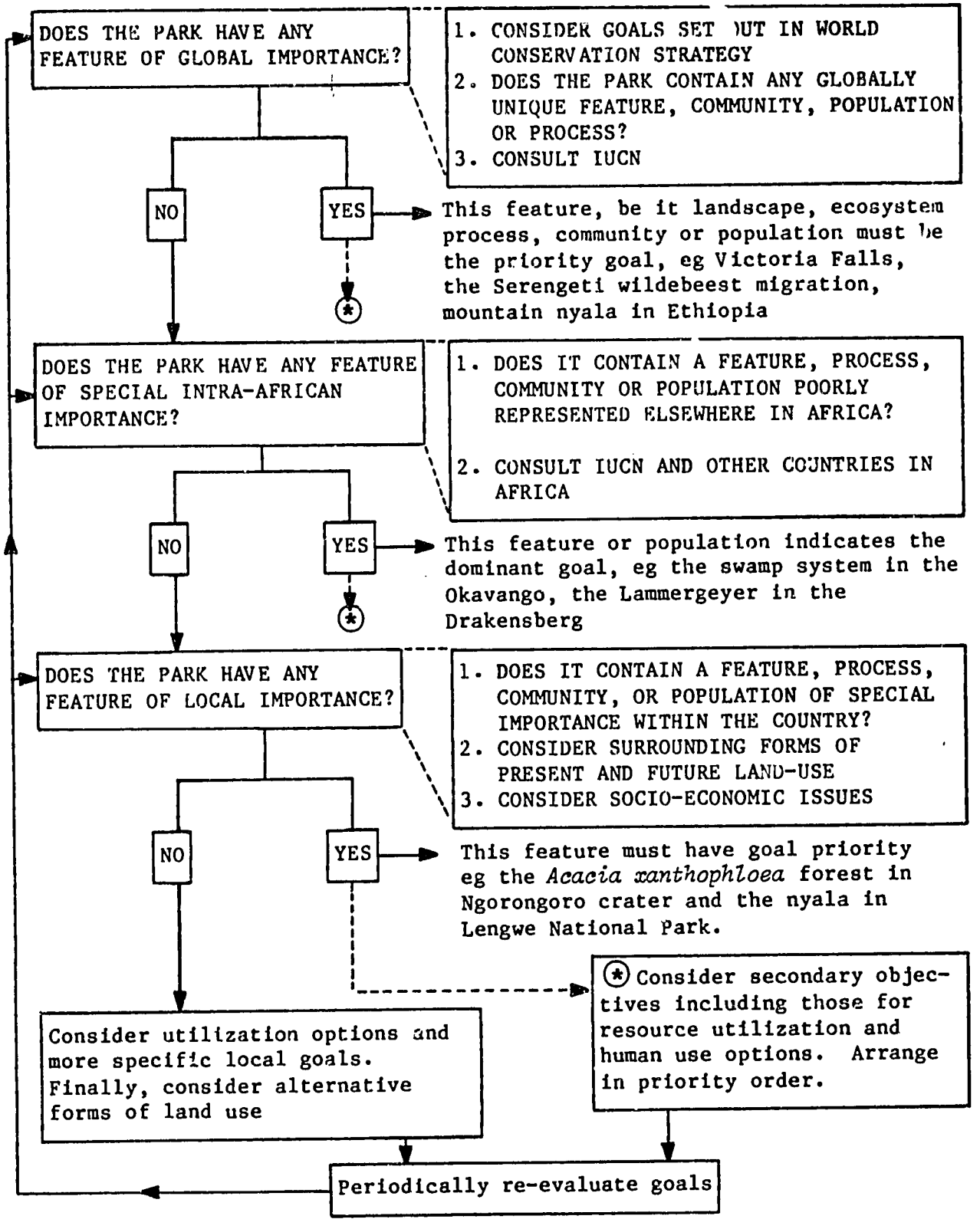

FIGURE 1.2. A decision sequence for selecting goals. The sequence follows an ecological order of dominance - the ecosystem - the biotic community, the population and finally the species.

- Legislative back-up. Are the goals compatible with present legislation? If not, either the goals or the legislation may have to be modified.

- Are there adequate natural resources, including land area, sufficient to allow the achievement of goals? Deficiencies here indicate that goals are unrealistic.

- Has the administrative system got the manpower, skills and executive capacity to achieve the goals? If not, then long-term planning must provide for training and expansion of these components.

Ranking goals according to priority

Various types of protected area have been established around the world to achieve combinations of these goals. These areas are known by a variety of names, such as national park, national monument, resource reserve, wildlife refuge or sanctuary, hunting area, game farm, botanic or nature reserve and wilderness area. There are many more. Conservation agencies are generally responsible for several such types of area. To clarify the relationship between possible goals and the full array of protected area categories for which an agency has responsibility, the following exercise is recommended.

A matrix should be constructed with all the possible objectives of the agency (such as those on page 4) listed on the vertical axis, and all the possible categories of protected area it controls or has any sort of responsibility for (such as an advisory responsibility), listed on the horizontal axis. The cells of the matrix may then be filled in, in the style of Miller (in prep), according to the relative importance of each objective for each type of protected area. An example of a grading system to indicate the dominance or priority ranking of objectives is as follows :

1 - Objective dominates the entire area.

2 - Objective dominates only part of the area through zoning.

3 - Objective shares dominance with other objectives over all or part of the area.

4 - Objective may be secondary to other objectives over all or part of the area.

5 - Objective is not applicable.

There are many ways of grading the dominance order of objectives, but whatever system is used this form of analysis will show up similarities and differences in how protected areas should be managed. It is particularly useful for policy makers and those involved in planning.

TABLE 1.1. An example of part of a matrix to analyse the priority relationships between objectives and types of protected area (adapted from Miller, in prep). Numbers refer to priority rankings listed above.

Category of area / Objective	National Park	Wilderness Area	Hunting Reserve	Recreation Area
Preserve genetic resources	1	4	3	4
Provide for visitor recreation	2 or 3	3	1 or 2	1
Production of protein or profit	5	5	1	4 or 5

HOW SHOULD GOALS BE STATED?

The goals defined for any protected area or conservation function should be formalised by means of specific policy directives. These should indicate to staff at all levels the administrative, planning, research and management options available. Once formalised, such a directive represents a logical delegation of authority, from the legislature down through the policy making level to the field manager. It should be a clearly stated, unambiguous document that is compulsory reading for all staff down to field manager level and should be freely available to interested members of the public. It is after all their park, so not only should they be informed of its objectives but they must be given effective means to question them and the way in which they are implemented.

The determination of conservation goals follows a series of logical steps. Goals may be defined and a suitable site then selected where these may best be achieved, as for example when a particular ecological process (ie the influence of variable rainfall on mammal population dynamics) is to be maintained by means of a protected area. More commonly, a protected area may already exist and it is a question of determining appropriate goals for it, taking into account global, continental, national and local priorities.

Consultation and discussion within the agency and, when appropriate, with representatives of the public, will lead to the refinement of goals. These may then be included in policy documents which are submitted for ratification to higher authority. The level at which this should be carried out will depend on the nature of the goal, the structure of the agency and the extent to which authority has been delegated to it and within it.

HOW DO GOALS FUNCTION THROUGH TIME?

Goals may change with the passing of time, especially with improving knowledge. They should be revised only through the same formalised procedures by which they are first set. All policies should be subject to periodic review and should be sufficiently flexible to respond to real changes in circumstances. However they should also be sufficiently entrenched to ensure continuity of purpose in the long term, and they should be sufficiently binding on all staff to ensure that they are given the best chance of being achieved in the field.

Finally, it is important to bear in mind both the external and internal perception of goals. First the external or public perception. For example; is conservation seen to be achieving its objectives, in reserves, in rivers, on farms, for a species, in legislation or internationally? It should be straight forward to measure this level of understanding. Second, there is the internal or staff perception of goals; ie, how does the understanding of goals serve to stimulate and direct the efforts of staff to achieve a common purpose? This is less easy to measure but is a vital component of all agencies and one that is commonly overlooked. All administrative, research and management functions must be directed towards the goals that an agency sets for itself. It is also essential that the objectives of the conservation agency must be seen by staff to be predominant over their own more limited goals.

GOALS - A PERSPECTIVE FOR THE POLICY MAKER

1. Overabundance is a condition that can only be suggested to exist relative to specified goals. Therefore the policy maker must select and define his goals. In practice this would be done by consultation, and ultimately made public in writing.

2. - A protected area is part of a natural ecosystem which is not static - it changes.
   - A protected area is not isolated from the influence of modern man. This influence operates at local, national and international levels and also changes.
   - A protected area is affected by ecological, financial and socio-political limitations which prescribe the range of possible goals available to the policy maker.

3. The range of possible goals is therefore limited and may change in time. There is no one "right goal", but a choice of several of varying importance. Therefore the policy maker must make a decision of preference; which goals suit his protected area and what is their order of dominance.

4. A goal selected for a protected area will not be achieved if it is not effectively pursued. Therefore managers must employ sound administrative techniques (ie good business management) to improve their chances of achieving their goals.

5. There is always inadequate but increasing knowledge of both the ecological processes within a protected area and of the relevant human attitudes. Goals and management actions must therefore be constantly re-evaluated by means of monitoring and research, and adjusted as necessary.

Chapter 2

WORKING WITH ECOLOGICAL IDEAS

Ecological concepts

Compilation led by
Graeme Caughley and Brian Walker

THE ROLE OF ECOLOGICAL CONCEPTS IN MANAGEMENT

CARRYING CAPACITY

ECOSYSTEM DYNAMICS

- Plant succession
- Stability and resilience
- Episodic events
- Population characteristics

KEY FACTORS

- Rainfall
- Soils and nutrients
- Surface water
- The catena
- Fire
- Intentional burning

AREA EFFECTS

- Size and diversity of habitats
- Absolute size effects
- Ecotones
- Fence effects - the interruption of animal movement

ECOLOGICAL INTERACTIONS

- Relationships between trophic levels - producers and consumers)
- Interactions within a trophic level - competition and facilitation
- Complex interactions

GENETIC CONSIDERATIONS

EXTERNAL INFLUENCES

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IN CONCLUSION

THE ROLE OF ECOLOGICAL CONCEPTS IN MANAGEMENT

The scientific basis for the management of natural ecosystems is a young, growing discipline. This chapter explores selected ecological concepts on which such management is based (Walker 1982), recognising that some are well tested, and can be used with confidence, while others that represent contemporary ecological thinking, may be modified as our understanding of them improves. There is always some uncertainty in applying these concepts. Many started off as nothing more than educated assumptions. As a result, mistakes are inevitable and all management activities should be planned to allow a healthy margin for error. In these cases, field management should be implemented in such a way as to test the validity of the assumptions on which they are based.

For example, a disease is assumed to be due to a trace element deficiency. The element is made available and the disease declines. However nothing is proved because the disease may have declined for some other reason. The manager could be sure that the disease was due to the deficiency, only if part of the area remained untreated (a "control" treatment), and the disease did not decline there over the same period. Hence conclusions based on evidence "before" and "after" a treatment are valid only if corroborated from other indepenedent sources. Complete confidence in a management action comes when results can be repeated at will under comparable circumstances.

It is important to distinguish carefully between cause and effect as this may be less obvious than it first appears. Accelerated soil erosion associated with poorly aligned, badly drained roads in Wankie National Park led to serious concern in the late 1960's. The cause of the erosion appeared to be the road drains, and measures were implemented to correct this. Closer examination showed that the roads simply acted to channel excessive run off. This was due to reduced perennial grass cover resulting from too frequent burning at the wrong time of year and overgrazing by large mammals and harvester termites.

Ecological processes and their consequences vary with time and place. Even where one sequence of events is predictable under certain climatic or environmental conditions, the end result may vary under different ecological circumstances. There will be many instances where readers are aware of these variations from their own experience. Where possible these should be fully documented in order to improve our understanding of the ecological basis for protected area management.

The following ecological concepts are offered as an aid to the planning of management actions, in the hope that, rather than being followed like a recipe book they will be used with a realization of their shortcomings. Most ecological processes are, in fact, counter-intuitive or "non-linear" in their cause and effect relationships and the only generalization that can be made about their consequences is that surprises will outnumber safe bets.

CARRYING CAPACITY

In its popular sense carrying capacity means different things to different people. In the context of these guidelines it is primarily determined by the aims of management in an area. By way of explanation consider cattle ranching, in which the objective is a maximum gain in weight per hectare. In this case the carrying capacity or optimum stocking rate will be well below the density at which weight gain per hectare is zero. This is a solid relationship that is not dependent on vegetational complexity or productivity and holds for both temperate zones and the tropics. Carrying capacity in this section is discussed mainly in relation to particular species. However, one should bear in mind that it is strictly a characteristic of the habitat, qualified in every instance by reference to the dependent herbivore or carnivore population. The term can be used to reflect a real or assumed limit to food supply, or that inseparable combination of food supply and space.

Suppose that the objective in an area is to conserve a rare plant, highly susceptible to grazing. The optimum density of the grazer is then far below (tending towards zero) that which yields maximum weight gain per hectare. Or take an area where the purpose is to allow an animal to reach its greatest trophy size in horns or tusks. This optimal density is calculated on the basis of maximum longevity of individual males. If however the objective is to conserve ecological processes, there is no optimum density at all, the species being allowed to achieve its own level which may or may not tend towards an ecological carrying capacity.

These four examples illustrate first that optimum density is determined less by biology than by human decisions, and secondly that the necessity to cull (the first two options) or not to cull (the second two) is determined almost entirely by the particular population density that is dictated by the chosen objective.

Since a commonly stated goal of culling is to hold a species density "within carrying capacity" it is worthwhile exploring what that phrase means. Ecologists use it to mean the density at which a population will stabilize if it is left alone. This is "ecological carrying capacity". Stabilization in this sense is not a steady density. There will be year to year variation caused by weather, and various fluctuations over longer periods particularly in respect of long lived species. Should the population live in the arid zone ecologists would be unlikely to use that term at all because the population's density is pushed up and down according to the vagaries of an unpredictable climate. "Carrying capacity" in such areas is often a meaningless concept.

Farmers and ranch managers use the phrase in a totally different sense. To them "carrying capacity" is the stocking rate at which maximum animal production per unit area is achieved. This is "economic carrying capacity". It can only be maintained by an annual offtake of animals in perpetuity. The relationship between these two concepts of carrying capacity is illustrated in Figure 2.1.

These differences, often unrecognized in the common use of the term, can lead to serious misunderstandings in wildlife management. One example will

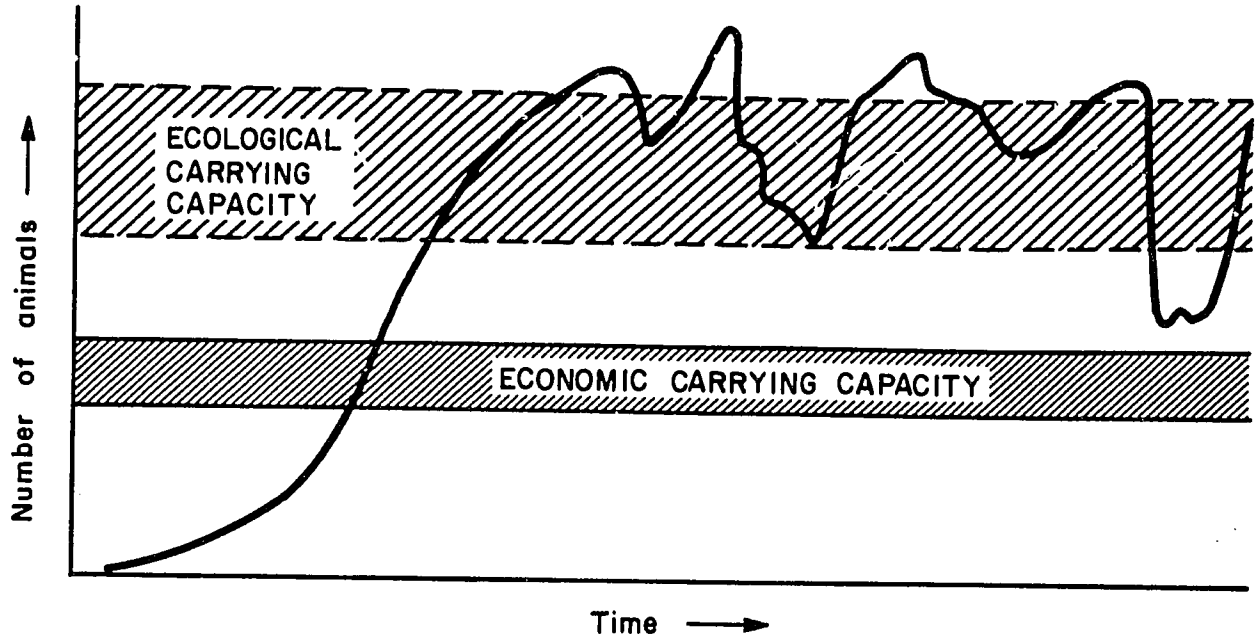

FIGURE 2.1. Schematic representation of ecological carrying capacity (the density around which an unmanaged population fluctuates) and economic carrying capacity (the density yielding maximum production of livestock). Ecological carrying capacity is a concept of population dynamics. Economic carrying capacity is the basis of the agricultural science of animal production.

suffice. Recently a field manager was asked to determine whether a national park was overstocked; whether certain populations were above carrying capacity. His training and experience was in the production of meat, so his concept of carrying capacity was tightly constrained by the ecological norms used in livestock production. His judgement was that the animals were well above carrying capacity and culling was an immediate necessity. He proved this by showing that the trend in plant composition and utilization was in the wrong direction from that which economic carrying capacity required. Neither he, nor the ecologists who called him in, realized they were at cross-purposes.

A common traditional understanding of carrying capacity in African wildlife areas is one based on a fixed perception of a habitat that looks natural (undisturbed), attractive and stable. Often this aesthetic vision of what Africa should look like is nothing more than a photographic impression obtained at a moment in time, and usually associated with free ranging animal populations sparsely distributed at well below ecological carrying capacity. It is not surprising therefore that when a high population of animals is seen to apparently cause this attractive, stable state to change, it is branded as undesirable and measures are taken to halt the process. Witness the concern over the conversion of the Kabalega and Seronera parkland savannas into grasslands in Uganda and Serengeti respectively.

There is nothing fundamentally wrong with this approach so long as (a) the relationship between cause and effect and management remedy can be clearly established and (b) that the objectives are realigned to the preservation of the aesthetic quality of the landscape.

In general, the longer a population's density is held below ecological carrying capacity, the lower is the system's ability to absorb change, and the greater will be the resultant disruption if active control of density is relaxed. For this reason, culling that has been in progress for some time should not be terminated abruptly. If it is stopped it should ideally be phased out over a number of years. The grazing system itself contains many stabilizing mechanisms (seasonal food shortages, varying palatability, competitive and facilitative feeders, etc) which can cause an overshoot if given free rein after the population has been held for some time below ecological carrying capacity.

These same mechanisms may also stop a manager from raising density to a desired level. As an example, cheetah were translocated into the Kruger National Park at a time when they were thought to be low in number. A few settled but most dispersed or died. It is now thought that the resident cheetah were at a "carrying capacity" imposed by the competitive influence of lions and therefore their density could not be increased artificially.

ECOSYSTEM DYNAMICS

Much of the disagreement amongst ecologists, and between ecologists and managers, concerning permissible levels of change in ecosystems, stems from differences in time scales, and differences in the uncertainty with which they regard permissible limits to change. The time scale implied in this section is a minimum of a few decades, and in some cases considerably longer. It is relatively straight forward to demonstrate some of the simpler, more established concepts of ecosystem dynamics such as plant succession (which is not saying that plant succession is simple). However, because of the long time scales involved and the relative newness of some aspects of ecosystem theory it is difficult to demonstrate or prove these concepts, for example those of stability and resilience.

Plant succession

Differences in vegetation are due either to inherent differences in the site (eg soil type) or to severe disturbance of one sort or another (eg fire, herbivores, man). Disturbed sites if left alone tend to develop back towards a steady-state or equilibrium composition and this process is referred to as secondary plant succession. The final stage of development, which is seldom if ever reached, is known as the successional climax, and the various intermediate forms of vegetation are known as seral stages.

The spatial pattern and diversity of the vegetation of a region is in part a product of disturbance, since it is only disturbance that ensures the existence of different seral stages.

In plant succession it is not only species composition which changes but also the ecological processes on which it depends, such as nutrient cycling

and control of topsoil microclimate. Early ideas that these processes increased and improved towards the climax, which is the "highest or best" stage, are invalid. Succession does not develop along a single path in this way. Early and intermediate stages are often the most productive and the climax is not necessarily the most desirable state. Notwithstanding these comments, climax forest and grassland vegetation is rare. Their species are relatively slow growing and long lived, and as a result include many that are threatened with extinction.

Stability and resilience

An ecosystem may be stable but have poor resilience. When undergoing change, an ecosystem may progress from a state of equilibrium or point of balance, towards a threshold or point of no return, from which it proceeds to a different equilibrium. These terms represent ecological concepts which need careful explanation. An example might be helpful.

Consider a wooded savanna with a low density of wildlife and frequent wildfires. It appears fairly stable, showing very little change over time. With protection, fires are controlled and wildlife increases, resulting in increased grazing pressure and a marked reduction of total food available, which further reduces the intensity of fires. This may result in increased pressure on mature trees and shrubs causing extensive coppicing and scrub encroachment, which further reduces the herb layer to virtually zero. The resultant dry unburnable thicket with reduced herbivore diversity may prove resistant to management efforts to reverse the trend. In fact it might appear more stable than the previous savanna woodland.

This hypothetical example illustrates an ecosystem with two equilibrium points of different stability. Under different soil and moisture conditions the thicket stage may be reached much sooner but under favourable conditions might return to a savanna structure. This situation could be described as having less stability but greater resilience.

The word "stability" has two separate but related meanings in ecology. The first more conventional meaning implies temporal stability which is simply the lack of change a system exhibits over time. The second meaning implies directional stability in which a system, when disturbed, will tend to return towards an equilibrium. A stable equilibrium is one that is difficult to disturb effectively for any length of time or in any direction. An unstable equilibrium is a fine point of balance which, provided the system is at that point, will stay there, but if disturbed even slightly, it will move away towards some different stable equilibrium.

In order to get to an alternative equilibrium point, a system must pass a threshold or point of no return. Once past such a threshold the rate of "change" may accelerate towards the alternative equilibrium point. As it is often impossible or impractical to retrieve systems from beyond such thresholds, it is necessary to concentrate research efforts on trying to identify them to predict and hopefully avoid the consequences of allowing systems to reach them.

A prime concern of conservation is the amount of change that a population, community or even a whole ecosystem can undergo, and still return to its original state or composition. This attribute is known as resilience. The word "resilience" implies elasticity in a system; one in which ecological change is readily reversible. Resilient systems are often unstable, in that they change a great deal over time (eg species composition changes) but they usually manage to recover following severe disturbance. In other words their thresholds are far from their equilibrium points. Both ecological theory, and practical evidence from fish and insect populations, suggest that if a system is maintained at a particular state or composition (artificially stabilized), its resilience decreases. It is only by allowing a system to fluctuate and approach its thresholds that resilience can be maintained, or increased. The implications for management are important; it seems illogical, but attempting to keep a system in some stabilized "optimum" condition may in fact ultimately reduce its ability to survive severe disurbances.

Let us use a variation of the wooded savanna example quoted earlier, this time on a soil type prone to surface sealing or capping. The resilience of the system appears to depend on the balance between grass and woody vegetation. A critical feature for the existence of the grass/tree combination (savanna) is the maintenance of a grass cover above a certain density. Below this particular density or threshold, soil capping may reduce the amount of moisture in the topsoil relative to the subsoil, thus favouring woody plants at the expense of grasses. This leads ultimately to thicket formation and probable surface erosion. These ideas and assumptions are currently being tested by research, but they are supported by evidence of changes from grassy savannas to thickets or chaparral in both Africa and America respectively.

In this instance the apparent conflict is as follows: a heavy grazing pressure could cause the grass cover to fall below the critical threshold. Resilience is conferred on the system by a high proportion of unpalatable or unavailable (prostrate) grasses which will keep the grass cover above the threshold despite heavy grazing. However, these unpalatable or unavailable species are inferior competitors and do not persist under constant light grazing. They are maintained only by periodic heavy grazing which depletes the more competitive palatable species. Therefore, to ensure that heavy grazing pressure does not reduce total grass cover below the threshold it is necessary to allow periodic heavy grazing pressure!

Episodic events

The dynamics of savannas and probably most other biomes containing large terrestrial mammals are to a large extent governed by the irregular occurrence of episodic events. As an example, processes such as tree mortality and successful establishment of tree seedlings do not occur as regular, annual events. Several years may go by (often longer than the duration of a research project) without such an event. The effect of such irregular intervals is to induce marked fluctuations in other competing or dependent species. The significance of the event increases with increase in elapsed time between such events. Examples are the importance of the rinderpest outbreak in southern Africa and the infrequent (once in 50

years) flooding over large river alluvia. In the latter instance such episodic flooding may be vital for the regeneration of particular floodplain trees (eg *Xanthocercis zambesiaca, Acacia albida)* and may control the development of termites and understorey shrubs.

Episodic environmental events that are of most significance in savanna regions are severe droughts, severe frosts, and years with very high rainfall. The coincidence of more than one such event can have serious and lasting effects - such as the "black" frosts in southern Zimbabwe and the lowveld of South Africa in the late winter of 1968. The frosts, which left standing dead scrub, were followed by heavy rains which produced exceptional grass growth, all of which gave rise to a dry season of phenomenal wild fires.

Animal eruptions are also episodic events. A population reacts to an increase in food or water availability, or recovers from low density to surge upward to a density peak which may be followed by a crash. An eruption in response to increased food, followed by overgrazing and a subsequent population die off, is an example of the negative feedback control that is built into most habitat/herbivore grazing systems. An eruption is not in itself a breakdown in stability but the means by which stability is enforced.

A management programme based only on annual or at least regular cycles, which does not cater for these episodic events, is unlikely to achieve its stated goals. The lesson for monitoring is that the short-term changes allowed for and recorded by a monitoring programme must be viewed in a long-term perspective which takes these periodic events into account. Failure to do so can lead, for example, to the conclusion that a lack of tree seedling regeneration for ten years represents something wrong, when in fact regeneration once in twenty years may be all that is required.

Population characteristics

There are three important characteristics of animal populations that have real implications for management. These may act singly or in combination but all relate primarily to a population's ability to increase, ie a comparison of natality and mortality.

a. **Intrinsic rate of increase.** A theoretical maximum rate of population increase can be established for all species from various physiological and nutritional characteristics. A growth rate below this maximum indicates that either the population is approaching ecological carrying capacity or that other factors may be increasing mortality (such as poaching) or depressing natality (such as disease or stress).

   Longevity, along with body-size is usually related inversely to breeding rate. Long lived species are invariably slower to achieve sexual and social maturity and have longer intervals between births. Large, slow breeding, long lived species are more vulnerable to management errors than those that are short lived with high growth rates and a potential for rapid recovery from environmental setbacks.

b. **Sex and age composition.** Many factors influence the age composition of populations, eg conception rate, birth rate, survival of young, age at puberty, territoriality and other behavioural characteristics. Fluctuations of these factors are manifest in changes in the death rate, usually only of specific age classes. For instance, a severe drought in the calving season will affect suckling young first, and the old, least fit adults later; territoriality can be expected to cause mortality specifically among younger and ageing adult males. The effect of drought on carnivores and herbivores may well be completely opposite. In short, the proportions of each age class change continuously and the theoretical notion of a stable age distribution (constant proportions of each age class year after year) almost never exists. Generally populations with a predominance of young can be expected to expand, while those dominated by older age classes can be expected to remain stable or decrease. In long lived species the length of time taken for an abnormally high level of recruitment to work its way through the age structure pyramid can be considerable, and can produce delayed effects on population increase.

A manager must be aware of the different ways separate sectors of a population may respond to stimuli. For example, in response to nutritional stress, a wildebeest population may lose an entire calf crop after a year of low rainfall. This must be seen as a normal and predictable adjustment to an environmental stimulus. If an economic objective were involved, management would attempt to anticipate the reduced grass production and cull accordingly. But not necessarily so if the objective were to conserve whole communities. A second example involves a response to spatial stress or territoriality. Lions respond by young males leaving a protected area thereby becoming potential livestock killers. A management response of reducing the lion population generally, would be less effective in preventing stock losses than one that reduced only the segment of the population involved, namely young males.

Haphazard influences on sex and age composition can greatly affect the rate of increase of small populations. Marked changes in population growth rates can occur, even annually, due to variation in mortality rates, age at which conception first occurs and variation in foetal sex ratios. For example, with elephants, even where numbers exceed a thousand animals, population growth rates may vary from 2% to 6% per annum (mean value c.4%) in successive years, through chance effects alone.

Whether or not to manipulate the sex and age composition of a species depends again on one's objective. In a sustained yield harvesting operation a preponderance of younger animals, just reaching adult weight and a maximum ratio of females to males, would be desirable. If a park's policy indicates minimum management, then a single large operation to dramatically reduce the breeding sector might be appropriate.

c. **Social organization.** Population dynamics of many large mammal species are strongly influenced by social factors such as

territoriality, average group size, seasonality of breeding, etc. These factors have many obvious implications for management. For example, a decision was taken to cull territorial male blesbok in the Rietvlei Reserve (Transvaal) in the belief that these animals prevented young "prime" males from breeding. This resulted in a marked drop in birth rate the following season as most of the remaining males became preoccupied establishing territorial dominance rather than breeding.

KEY FACTORS

The structure, species composition and productivity of vegetation communities, and the continuity of ecological processes, are determined by only a few crucial factors. Some are inherent features of the site (eg soil type) and others may be man-imposed (such as fire). It is the susceptibility to change of these key factors that determines how the ecosystem will respond to man-induced influences.

Rainfall

For many African savanna ecosystems, plant productivity and hence large herbivore biomass are closely related to rainfall. However, this relation ship is modified by soil type and nutrient availability. Within a given climatic zone, at least for southern Africa, extended periods of lower or higher rainfall occur in apparent cycles of between 10 and 15 years. The consequences of these cycles for large mammal populations are usually more extreme in arid areas, in spite of the ability of these habitats to recover rapidly from periods of heavy grazing such as may accompany a dry cycle. The frequency of fire is also affected; by the amount of grass growth. The significance of these cycles to management lies in the correct interpretation of habitat changes. Observed changes could be attributed to herbivore overabundance when they may have been due to exceptional rainfall.

Soils and nutrients

Different soils have different properties, such as moisture and nutrient content, and therefore support different vegetation types. A sandy soil allows rapid water infiltration while at the same time permitting easier water uptake by plants. Clay soils have a lower infiltration rate but higher moisture retention. Both small and large scale variations in plant communities can be attributed to such soil properties. An example of large scale variation is the difference between the miombo and mopani communities which replace one another on light (sandy) and heavy (clay) textured soils, respectively. The prime example of small scale variation is of course the presence of termite mounds or "ant hills" which form such an ecologically important feature in many African landscapes.

Soil water balance is a primary factor in determining vegetation structure. Pure grasslands in savanna regions are usually due to hydromorphic soils (soils that are regularly waterlogged for at least part of a season). Vleis and dambos are obvious examples but, perhaps less obviously,

grasslands also occur on flat plains and in lower catena positions and on soils with an underlying impervious layer such as calcrete or laterite. These grasslands are sensitive to changes in water regime, as demonstrated by Tinley (1977) in Gorongosa (Mocambique) and elsewhere. An extreme example, is "pulling the plug out of a vlei", whereby incision and drainage at the lower end of a vlei or grassland sponge leads to deep drainage, drying out and subsequent invasion by woody species.

Nutrient status of the soil is influenced by rainfall and soil texture. A high rainfall induces leaching of minerals, particularly from sandy soils, resulting in low fertility, whereas clay soils show less short-term leaching despite high rainfall. However where rainfall does not infiltrate into the soil it cannot leach nutrients, as in the case of soil capping. (In this case, if there is a saving in the leaching of nutrients this advantage would probably be cancelled by increased runoff and erosion.) Low infiltration rates and low soil nutrient levels tend to produce low quality, acid grasslands, which support a low biomass of small selective grazers such as reedbuck. Miombo woodlands on infertile sands support a low biomass of browsers and grazers, including elephant, buffalo, sable and roan. As the clay fraction of the soil increases, so does its nutrient status and the moisture retaining capacity of the topsoil. This gives rise to a higher ratio of grass production to woody production, and more palatable and nutritious vegetation.

Infiltration of rainfall is generally inversely related to an increase in clay content, but is also markedly affected by vegetation and litter cover. As grass and litter cover decline, so does infiltration rate. Ecosystems are least sensitive to disturbance where infiltration rates are high, and similarly where nutritional value of plants is low. The major management problems occur where high levels of soil nutrients produce preferred food plants and where soil conditions or topography give rise to reduced infiltration and/or high rates of soil erosion (eg soils with a potential for capping, areas with physically impeded drainage, sodic soils, erodable soils on sloping ground etc).

Surface Water

Surface water supplies have an obvious controlling influence on animal dispersion and movement. Herbivores often show extensive seasonal movements in response to the availability of surface water, as exemplified by the concentration of elephant and buffalo in the Chobe/Savuti area of northern Botswana in October. As a result of this uneven feeding pressure on the ecosystem it is important to determine the seasonal intensity of grazing and browsing. In this way the habitat imposes a variable but strict limit on the absolute numbers of species that survive each dry season, determined by the reserves of food available within reach of perennial water. In large restricted areas where there is room for these movements to continue reasonably unhindered it must be assumed that their effects on vegetation still operate. Plant communities become adapted to naturally induced non-grazing periods either in the growing or non-growing season. However in small fenced reserves or where widespread supplementary drinking water has been provided these controlling factors are effectively removed.

The provision of drinking water alters and often rigidly stabilizes the natural pattern of animal distribution. This results in excessive use of the range in the proximity of the water supply, sometimes giving rise to a reduction of grass cover and bush encroachment. This is particularly critical where solitary boreholes are situated in large, previously waterless areas where the natural dispersion patterns are most extreme.

Somewhat less obvious, but probably of greater significance, is the fact that artificial water supplies can produce unforeseen consequences in distant areas. By allowing the survival of increased numbers of animals through the dry season, the favoured wet season habitats become subjected to much increased grazing pressure. For example in Mkuzi in Natal, dry sand forest provides habitat for the little suni antelope. Provision of artificial water points has boosted populations of impala and nyala, causing marked reduction of both herbaceous cover and low level browse for some considerable distance from the water points. This loss of food supply to the suni and invasion by unpalatable scrub has resulted in a serious reduction of this rare species.

The catena

Figure 2.2 illustrates the common intergraded changes which characterise topographic soil/vegetation patterns at a fine scale. Generally the nutrient-poor, coarser soils are in the upland position with the finer more fertile material in the bottom lands. Such a soil or vegetation gradient is known as a catena.

Vegetation gradients follow these soil changes quite closely. An example from the extensive miombo woodlands of the western regions of southern Africa provides a useful example. The soil/vegetation gradient progresses from well grown *Baikaiea plurijuga/Brachystegia boemii* woodlands on normal upland (the elluvial soils in this case, being uncharacteristically deep kalahari sands), through to *Burkea africana/Terminalia sericea* woodland and scrub on the slopes (the colluvial soils being shallower with a slightly higher day component). In the bottom lands there are hydromorphic soils and/or impeded drainage zones supporting mixed grassland, with sometimes a thin wooded fringe of *Acacia* spp/ *Combretum* spp along water courses.

Fire

There is little information on fire frequency in the absence of man in African savannas, apart from the fact that it increases with rainfall up to the point at which forest communities develop, after which it falls to a very low level. However, *"Homo sapiens* var *pyrophilos"* has been around, living off these rich grazing lands for so long that cutting a fine distinction between "man-induced" and "natural" fires is wasted effort. The practice of traditional, deliberate burning of all except the arid and moist extremes, was probably responsible for the open appearance of African savannas as described in the earliest written records. In the least developed areas of some countries this influence can still be seen functioning today. However some localities with specific weather patterns do have a high frequency of lightning initiated fires (eg montane grasslands).

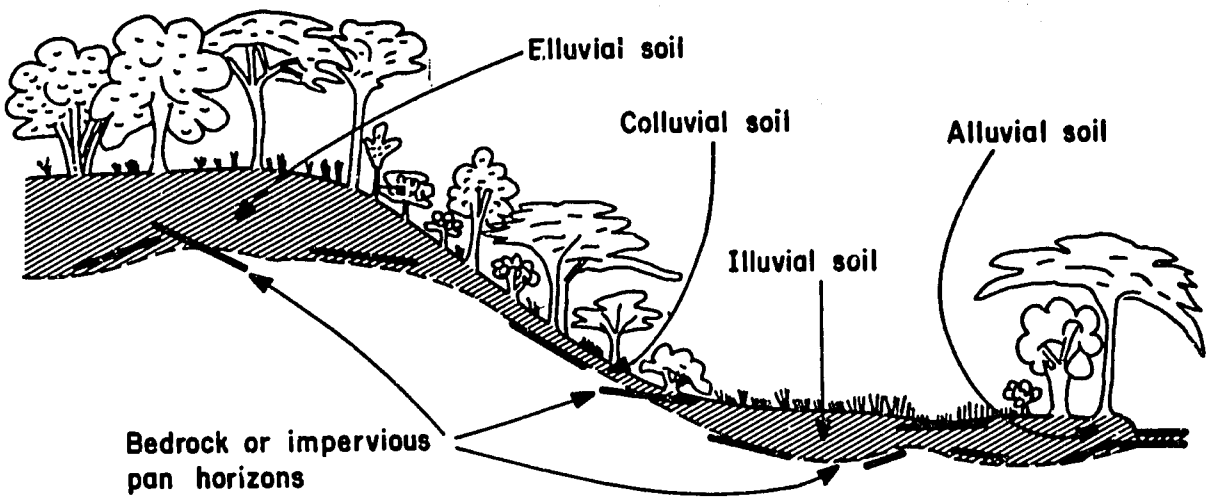

FIGURE 2.2. A representation of a miombo soil/vegetation catena.

Fire can modify or divert vegetation succession by removing unpalatable herbage of low nutritional quality, and stimulating the production of new grass of higher nutritional quality. By weakening the grass cover and thus reducing root competition in the topsoil, frequent burning in semi-arid regions can promote an increase of tree and shrub species.

In woodland systems the frequent use of ground fires to maintain range conditions suitable for grazing animals may jeopardize tree regeneration, thereby threatening woodland continuity. Conversely, in savannas the elimination of fire either deliberately by man or by heavy grazing, can lead to shrub encroachment.

The heat of a burn depends upon the fuel load, the timing of the burn, and weather conditions such as temperature and wind speed. The fuel load is affected by the moisture content of both living and dead fuel (mainly grass). Generally the fuel load accumulates with time, reaching a relatively constant level after several years when accumulation equals decomposition. Decomposition rate is greatly affected by agents such as termites, trampling, saprophytic fungi and frost. Early burning, when the moisture content of the vegetation is high, produces a cool fire that has least impact on living plants (especially woody vegetation). Another important factor about early burning (early in the dry season ie June and July in southern Africa) is that it also does least damage to insects, birds and other small animals which are mostly in the least active phase of their annual life cycle (eg sap is not rising in palatable shrubs, reptiles are underground, ground nesting birds are not breeding, etc).

However it is known that insect herbivores have a great impact on vegetation, and yet the effect of fire on these populations is almost completely unknown. In open (non-woodland) vegetation wind speed is a most important weather factor. A head-fire burns fast, dissipating most of its

heat upwards, whereas back-burning into the wind produces a slow fire that is hottest close to the ground. To control tree and shrub encroachment a hot, late dry season head-fire is required. A back-burn with a high fuel load on a hot dry day will cause severe damage to the grass sward.

Apart from the conditions at the time of the fire, some types of ecosystem are inherently more sensitive to the influence of fire than others. For example, vegetation on deep, semi-arid sands has a high proportion of root biomass and therefore has sufficient food reserves to flush repeatedly after frequent burning. Furthermore, baring these soils by fire does not lead to soil capping and erosion, as it does on some fine-textured soils. At the other end of the soil spectrum, grasslands on heavy basaltic clays with a high water table may also be burned frequently with little risk of deterioration. In such situations growth is vigorous and the vegetation often unpalatable, except soon after a burn. The self-churning nature of the clays prevents soil capping and its glue-like consistency when wet is a deterrent to heavy grazers, which gives the vegetation a mid-growing season rest.

Burning has a whole range of different direct and indirect effects on large mammal populations. It may attract some and repel others, and then reverse the trend after a growth flush has appeared or if the burn is conducted at a different time of year. Herbivore response to burnt areas will also depend on what other options the animals have at that particular time and place.

Intentional burning

The role and value of fires in African grasslands and savannas are only beginning to be understood. Its effects are complex and variable and it is not our intention to give an account of them here. It is sufficient to say that fire is one of the most effective tools available to the wildlife manager and that he will only be able to use it effectively if he takes the trouble to learn precisely what effects it produces in his particular area. Generally speaking, the more fuel, the greater the potential available to the manager to manipulate the ecosystem by use of deliberate burning.

A general objective of intentional burning could be to try to represent the assumed primeval fire regime of an area. When this is the case, emphasis should be placed on flexibility and on burning relatively small patches, well distributed in time and space. In areas of variable rainfall it is not advisable to practice controlled burning on the basis of a rigidly fixed frequency for specific vegetation types. It is better, if possible, to determine the real purpose of the burn and then to judge whether the fuel load and circumstances of the timing of the burn will produce the intended result. There are a limited number of primary purposes served by intentional burning:

- to remove dead herbaceous material in order to revitalise the grass sward,

- to control excessive encroachment of woody species,

- to provide a limited, high quality food source (often out of season) from grasslands that have sufficient reserves of nutrients and moisture,
- to pre-empt wild fires which have a potential to initiate undesirable changes to the system (for the sake of completion, this includes fire breaks).

There are several possible subsidiary purposes such as; to assist in tick control, to alleviate grazing pressure on nearby areas, to improve game viewing for tourists or to increase the feasibility of hunting. However these are generally not sufficient reason on their own, for intentional burning in a protected area.

AREA EFFECTS

Size and diversity of habitats

The greater the size of an area the greater the variety of habitat types it is likely to contain. Where animal communities are involved, increased size therefore provides greater choice of habitats and food supplies both seasonally and spatially. This leads directly to animal populations being better able to avoid the more extreme effects of environmental change and therefore greater stability and resilience in the system. Variation in the quality or content of habitats is termed its diversity, and variation in its pattern or spatial distribution is termed its heterogeneity. These two characteristics of habitat quality are interlinked and often highly correlated.

Habitat variability is largely dependent on geological substrate, soils and variation in weather patterns. It can be affected at a small scale by chance events, such as a fire caused by lightning which results in subsequent heavy grazing, which in turn initiates a vegetation trend different to that of the surrounding area. Similarly, old-style shifting agriculture imposed a characteristic patchwork of successional vegetation on the landscape. The larger the area, the greater the possibility that either one or a combination of the above factors will vary in space and time. As a consequence, habitat heterogeneity is normally greater in large areas.

Habitat heterogeneity strongly influences the stability and resilience of the system as a whole. For instance, the variation in location and timing of rainfall over the Serengeti system (a fairly uniform region) may impart stability to the wildebeest population. Thunderstorms result in a patchy distribution of green grass. These patches are continually being occupied by wildebeest from adjacent patches when the latter cannot sustain further grazing. If a percentage of the wildebeest population were confined to an equivalent portion of the overall range, the number of patches available for them to feed on would be reduced, resulting in an increased probability that food would become limiting within the confined area. The likelihood of a population crash is thereby increased and the stability of the system decreased by reduction in area (Sinclair and Norton-Griffiths 1979).

Absolute size effects

The size of a reserve has a number of additional effects on the plants and animals within it. A very small reserve can hold only small populations of animals, which puts them at risk from the point of view of low genetic variability. This may lead to extinction in the case of rare species or ecotypes.

Recent work on island biogeography suggests that reserves comprising "islands" of wildlife habitat are prone to loss of species. Reserves that are small, or angular in shape, or of low habitat diversity will probably loose species faster than those that are large, or of compact shape, or diverse in habitats. There is still no consensus on the time scale involved in this process or on what precautions can be taken to prevent it. Loss of species is probably haphazard and unlikely to affect different reserves in the same way. A comprehensive protected area system may cater for this risk by ensuring that its more valuable conservation "eggs" are not all kept in single baskets. The message for the policy maker is that if the elements being protected are small, they should be many.

Closely related to the ideas of island biogeography is the much older, but no less useful, theory that there is an ideal number of species for a given area. These species/area relationships indicate that there is an optimum balance of species for any given area. Many reserves may presently contain more species than they can sustain and so run a high risk of losing those that are susceptible to the effects of confinement. In small reserves it may be unwise to try, by translocation, to build up a faunal community characteristic of a whole region. Small areas are unable to provide sufficient variety of habitat and seasonal food supplies to accommodate such a "compressed" community, and the high management inputs needed to maintain it are likely to guarantee only ever-escalating management inputs. These considerations suggest that research is needed to provide a sound basis for determining the minimum size that a protected area should be in order to achieve its stated objectives.

Ecotones

An ecotone is defined as the area of contact between two plant communities. This transitional zone may be narrow in the case of an abrupt change, or it may be relatively wide with a gradual gradient between communities. Utilization of ecotones by animals varies but often they are used more intensively than either of the adjacent communities because they contain elements from both, and perhaps elements peculiar to ecotones. Because of these and other more subtle factors, ecotones tend to be zones of tension and focal points of wildlife habitat. They may be sensitive to pressure and probably have a lower resilience than the more homogenous habitats on either side of them.

Diversity in the structure and species of plants associated with ecotones favours many species, such as Lichtenstein's hartebeest and bushbuck, and is usually reflected by increased diversity of the fauna. It follows that there may be advantages in having a high frequency of well conserved ecotones and a mosaic of varied habitats within a protected area. High levels of diversity and heterogeneity of habitats are a real asset in any protected area.

There is one animal that has a particular affinity for ecotones. With uncanny regularity its feeding sites and burrows, resting places and lookout points, to say nothing of its middens and intricate network of heavily used trails and fire defence mechanisms, are all placed right along the ecotones. It must be something to do with his highly evolved aesthetic sense of space and setting, a place with a view, possibly linked to a primitive need to skulk around within leaping distance of the shrubbery! In the past, park managers have often been a considerable threat to the ecotones in their protected areas. Thank goodness, in the last few years this has been recognised, but the temptation will always be there because ecotones do provide some of the most attractive development sites in our parks and reserves.

Fence effects -- the interruption of animal movements

There is a growing body of evidence that fences around wildlife conservation areas lead to problems. They may concentrate animals, with consequent overgrazing or they may deny animals access to certain essential habitat resources. In the Etosha system in SWA/Namibia for example, the wildebeest population declined from 25 000 to 2 000 head, apparently as a result of a fence that inhibited seasonal migration. The increased predation by lions and resultant decline in a major herbivore population led to a chain reaction of ecological events, varying from epidemic diseases (anthrax) to unusual predatory competition between lion and cheetah (Berry 1980). Fences also inhibit natural dispersal mechanisms, contributing to overuse of enclosed food supplies. In addition there is theoretical evidence that they may promote more extreme fluctuations in animal numbers, especially in small areas with limited diversity of habitats (Owen-Smith 1983).

ECOLOGICAL INTERACTIONS

Ecological interactions take place between species occupying different trophic levels in the ecosystem. Plants are influenced directly by factors of the physical environment: water and nutrient availability; temperature; wind and sunlight; but their growth and density may be considerably modified by herbivorous animals. Herbivores are influenced by the plants they eat and by the carnivores that in turn eat them.

In practice these categories are not always so neat. Jackals eat both vegetable and animal food, and are themselves often preyed upon by leopards. Species occupying the same trophic level (utilizing the same type of food) may compete for requirements such as food and cover or simply for space. It is this web of interdependence which binds species together into a community. Management action affecting one species may have unforseen consequences for a species several links away in the food web. For example, the loss of predators (including raptors) in the eastern Cape Province of South Africa contributed to an increase in hyraxes, which reduced the food available to competing herbivores, in this case domestic sheep.

Whether a species can exist in an area depends upon the degree to which the area can provide its life needs; adequate food, water, breeding sites and cover for protection from predation and extremes of weather. These are the more important components of its ecological niche. Any one factor may be more important than the others and interactions between factors also occur.

Relationships between trophic levels - producers and consumers

The availability of food is a dominant component of habitat suitability, especially for large mammals. Three components of food availability need to be distinguished:

a. Overall abundance, that is the amount per unit area, of the organisms or parts of organisms that are edible to the consumer species. Note that edibility is also dependent on the physical characteristics of the ingestive and digestive adaptions of that species.

b. Accessibility of food items. Leaves in the canopies of tall trees are unavailable to antelope until they fall. Underground food supplies are available only to species capable of digging such as warthogs and porcupines. Thorns and similar deterrent structures on woody plants may protect some of the leaves from browsing ungulates. Defensive chemicals such as resins and alkaloids may provide similar deterrents.

c. Nutritional value of the food. This is influenced by its content of digestible carbohydrate and protein and other nutrients such as vitamins, essential fatty acids and specific trace elements.

animal must eat fast enough to be able to gain more energy than it expends in living. Energy costs are influenced by the distance an animal moves in seeking food and water, cover or shade and in avoiding predators. During critical periods, an adequate intake of nutrients may be possible in only a few key areas which are then vital if a population is to survive or prosper. For example, buffalo depend on valley grasslands which retain some green leaf during the dry season, and kudu move to wooded hillsides to seek out reserve sources of browse.

Some "broad-niche" species are tolerant of a wide range of habitat conditions. A prime example is the impala (besides the obvious example - elephant) which feeds on both grass and browse, and occupies a wide range of habitats from open savannas to relatively dense thickets. Other "narrow-niche" species are more restricted. Tsessebe or topi often favour the moderately tall grasslands of plains and depressions. They are widely distributed and abundant where their habitat requirements are met, but are localized and vulnerable if those habitats are fragmented or of limited size.

Interactions within a trophic level - competition and facilitation

Competition does not necessarily result from animals eating the same things. They may be separated by favouring different parts of the same plant. For example wildebeest eat mainly the green leaves of grasses under about 10 cm in height, while zebra tolerate a higher proportion of stems in their diet. Topi use their narrow muzzles to select green leaves from taller grasses. Consequently species may select different habitat types despite similarities in their diets. A good example may be taken from the predator community. In woodland and scrubby habitats, lions are successful hunters using cover to stalk their prey, while hyenas generally scavenge lion kills. In more open areas and grasslands these roles are often reversed.

Overlap of food requirements has little effect when food is plentiful. During critical periods such as the late dry season, species become more clearly separated by competition for food. Wildebeest, zebra, impala, warthogs and white rhino favour the same short or succulent grasses during the wet season. But during the dry season impala turn to browse, warthogs dig for grass rhizomes, wildebeest wander widely, seeking out green flushes resulting from rain showers or fires, while white rhino and zebra make use of stemmy stands of taller grass. During droughts populations may spread into habitats they do not normally occupy. Under these conditions an abundant species may deplete the food of a rarer species, causing the latter to be displaced. This may not be due only to direct competition for food; sheer physical domination of an area, and habitat modification by trampling or breakage of woody plants may be sufficient to eliminate more specialised species.

Facilitation occurs between species feeding on similar food sources when the activities of one species actively benefit others. By grazing or trampling tall grass buffalo can open up these areas for use by species favouring shorter grass. For some habitats this grazing sequence, from heavy, non-selective feeders to smaller, more selective feeders, has been clearly described (Gwynne and Bell 1968). Among browsing species similar facilitative feeding takes place with the reduction of tree canopies and scrub to lower levels. In more complex habitats similar but less obvious relationships probably exist.

Complex interactions

Ecological interactions between species are usually complex and often surprising. For example, the continued survival of the mature acacias of the Seronera woodlands in the Serengeti is threatened, apparently because elephants are killing the large trees. Intuitively, the most obvious remedial action is to cull elephants. Research suggests, however, that even if all the elephants were eliminated, the woodlands would not recover because there are too few young trees to replace those that are dying. If healthy populations of saplings could be established and their survival to mature tree size encouraged, this would more than compensate for the mortality in large trees. There are of course other major factors involved in the establishment and survival of trees. Fire retards or prevents their establishment, and browsers, in this case notably giraffe, modify growth forms and jeopardize survival (Pellew in prep).

There are other, more complex and poorly understood, factors. How do sparse, single age stands of trees with palatable foliage maintain themselves at all in the presence of browsers? In some cases it appears that they do not, and will inevitably be replaced by a quite different vegetation type. The message for managers is quite clear, there are more ways of keeping tree populations viable than by killing elephants. Less obvious consumers from insects to competing herbivores and the ubiquitous effects of fire must always be anticipated as sources of subtle ecological influence.

Where major vegetation changes do have a potential to proceed to extremes because of herbivore impact, there are mechanisms that stabilise the producer/consumer relationship. One such mechanism is the ability of animals to switch to an alternative food source once intake of favoured foods falls below critical maintenance levels.

GENETIC CONSIDERATIONS

Long distance translocation of animals is an increasingly important management response to the problems of over- and under-abundance, as evidenced by the transfer of white rhino from Natal all over southern Africa.

Species comprise sub-populations that are genetically distinct (ecotypes) and possess adaptive characteristics for their particular environments. Introduction of populations from elsewhere leads to mixing of two gene complexes. Where local animals are inferior competitors or are few in number it may result in the elimination of the genes selected for that environment. Therefore, translocation is only really safe when animals are to be introduced into an area where no locally evolved individuals survive, or where the numbers are below the minimum viable population (whatever that may be).

"Maintenance of genetic variability" is a major objective of conservation. In essence this means the maintenance of all the different gene complexes that occur within a species. The fine degree of variation that exists between ecotypes represents the forefront of evolution, and maintenance of genetic variability ensures that future options for the adaptive development of a species are not closed. The significance of this to management is that ecotypic variation can occur over short distances, and a number of ecotypes may occur within one region. This is particularly so for plants, but locally adapted sub-populations of mammals may well occur within the conservation areas set aside by one particular conservation body. As an example, the elephant of the Gona-re-Zhou in Zimbabwe are genetically distinct (shown by electrophoresis of blood proteins) from those in Wankie. Genetic distinctions are likely to be even more marked over long distances (eg the black rhinos of eastern and southern Africa).

EXTERNAL INFLUENCES

All protected areas are part of the region in which they occur and are subject to socio-political and ecological influences from outside their

borders. The former are discussed in Chapter 3, while selected ecological impacts are touched on here. The most serious are those affecting the whole region or catchment of which the reserve is a part, whether they emanate from close by or a considerable distance. River flow and the seasonal availability of water in the area may be affected by upstream irrigation schemes or erosion and siltation due to poor farming many hundreds of kilometres away. Likewise, alien plants may invade or birds introduce diseases from distant sources. More localised impacts may include regular fires entering the area from a neighbouring property, or nearby unprotected livestock or crops that may attract predators or crop raiders from within the reserve.

The reserve manager should recognise that he may have few options and can but seek to cushion the effects without being able to eliminate their underlying causes. His best bet is to develop an understanding of his surrounding areas and catchments so that he can predict such events as the introduction of alien species; changes in water regimes or the biological, chemical or physical (silt load) properties of water bodies; changes in bird communities (especially raptors); changes in human and livestock densities around the reserve and their likely impact; and shifts in neighbourhood attitudes with a likelihood of this leading to conflicts such as increased poaching or trespass. Ideally these potential influences should be regularly recorded as part of the reserve's formalised monitoring programme.

Managers should also ensure good public relations with neighbouring communities and should always try to demonstrate the value of the protected area to the wellbeing of the region as a whole. This can include making its technical expertise in land management available to local communities; taking an active role in local affairs and assisting with local problems and providing some sort of specific interpretive effort in conservation education and public understanding.

IN CONCLUSION

The world is not simple and things are not always as they seem. In many instances the obvious management response to a problem is not appropriate, it may even produce an effect directly opposite to that intended. This reflects the inherent difficulty in establishing cause and effect relationships in complex, poorly understood systems. Change in itself is not a bad thing, it is in fact a requirement for the maintenance of high resilience. In many cases culling is by no means either the conservative or the safe option. The more one tries to prevent change, the more management effort will be needed to sustain ecosystems into the future.

Chapter 3

WILDLIFE AND SOCIETY

Socio-economic and political considerations

Compilation led by
Tony Ferrar

BACKGROUND TO THE PROBLEM

HUMAN DENSITY AND TOLERANCE OF WILDLIFE

EXTERNAL ATTITUDES AND THEIR INFLUENCE ON PROTECTED AREAS

- International influences
- The anti-killing ethic

NATIONAL PERCEPTION OF PARK VALUES

CONSTRAINTS AT THE LOCAL LEVEL

- Conservation of montane habitats
- The case of inflexible legislation
- The economic option

STRATEGIES TO INCREASE ACCEPTANCE OF CONSERVATION

- General public awareness
- Land use planning
- Legal and administrative procedures
- Rural education - land use advisory services

MONITORING SOCIO-POLITICAL ATTITUDES

ENCOURAGING PUBLIC SUPPORT

IMPLICATIONS OF ALLOCATING PROTECTED AREAS TO SPECIFIC CATEGORIES

IN CONCLUSION

Previous Page Blank

BACKGROUND TO THE PROBLEM

The socio-economic and political pressures that increasingly confront the protected areas of Africa are the most critical issues facing conservation managers. In all African countries, including the most developed, these pressures are building up to such a level that they threaten to engulf the very areas that have been set aside for protection(eg Parc des Volcans, Rwanda; Lochinvar, Zambia; Hluhluwe-Umfolozi, Natal). Unless these mounting pressures are recognised by conservation planners, and unless creative steps are taken now to accommodate them, wildlife areas can survive only by escalating the use of force against a hostile rural public. Cooperation is a more realistic approach than coercion.

Apart from the overriding effects of Africa's human population crisis, the origins of these pressures are complex and often emotional. Essentially they arise from the fact that, at any but the lowest density, large wild animals and humans are fundamentally incompatible. This incompatibility increases rapidly as both animal and human densities increase. The urgent necessity now is to reconcile wherever possible this competitive demand for resources. With imagination and goodwill this is a difficult but not impossible task. The need now is for (conservative) conservationists to acknowledge these important pressures and, where possible, to accomodate the aspirations of people who are negatively affected by the use of land for conservation purposes.

The attitude of many conservationists up to now has been one of reluctant compromise. Faced with an increasing demand by an insistent public the typical response has been to give a little (meat, firewood, grass for thatching, etc) in the hope that this, at least temporarily, will satisfy their more reasonable demands. Such action is inevitably retrospective. This negative approach needs to be replaced by a willingness to adopt a broader and more flexible policy in the management of conservation areas. This must include the concept of limited multiple use of the renewable resources of certain reserves, either within them or in zones around their borders.

There is no doubt that competition for resources between conservationists and local land users is accelerating. The combination of increasing numbers of human beings, their depletion of rural resources and their increasing expectations for improved living standards exacerbates the problem. But while population pressures have increased, the evolution of the conservation ethos has lagged behind. This is most notable among some African tribes who had highly evolved conservation and land use customs. Mostly, these have died in the establishment of a suitable modern ethic for land use, now such a desparately urgent priority.

Most conservation areas were established in surroundings of low human density in the belief that wild plants and animals in wild surroundings could best be saved from extinction by isolating them from human influence. This was implemented with little regard for the negative impacts on surrounding land users.because they were few. The last two decades have seen rapid progress in ecological thinking and in the application of new concepts to the management of protected areas. These advances now urgently need to be matched by similar progress on two other

fronts. First, in the application of ecological concepts to areas outside these reserves (initially in adjacent lands) and second, in the realisation that equivalent sociological concepts and progress will also have to be developed, if sustainable land use is ever to be achieved.

In recent years the world has become increasingly concerned with environmental matters. In the developed nations, major physical developments are implemented only following a favourable environmental impact assessment which has examined social, economic and environmental factors. Conservation planning should also be subject to some form of impact assessment which must include increased emphasis on social issues, and involve expertise from the social sciences. There is an ironic situation in the field of conservation in Africa. It could be said we know more of the behaviour of elephants than we do of the people they are in conflict with. If this chapter does nothing else, we hope it will stimulate thought and action in terms of human/land/conservation interactions.

HUMAN DENSITY AND TOLERANCE OF WILDLIFE

History suggests that there is a relationship between tolerance of wildlife, and human population density. Where humans are few there is acceptance of wild surroundings, which itself may be the major source of food and other resources. Where people become numerous the relationship progresses through time from acceptance to intolerance.

The present rise of human populations in Africa indicates that there will be a progressive decline in rural people's tolerance of extensive wildlife areas. Conservation areas will shrink as the number of people dependent on the land rises. Extensive wildlife conservation areas have a greater chance of survival if policies are adapted to obtain the concurrence of the people whom they directly affect.

If this analysis is correct it is likely that at any given human density there will be a range of attitudes to wildlife from intolerance to some degree of acceptance (Figure 3.1). A human community's position in this range will be determined by the amount of hardship or benefit that results from use of the land for conservation. It is here that the administrator has the opportunity to reduce or deflect conflict. Management policy should be designed to persuade people to change their attitudes, from intolerance to tolerance or from mere tolerance to acceptance. By such policies the slope of the curve relating increasing density to increasing intolerance will be reduced and the timescale of events thereby extended. This may be achieved best by the zoning of parks and their adjacent lands for types of use that integrate conservation needs with those of adjacent human populations and by a positive education policy in the region. Policies may be quite different for urban populations, or those distant from protected areas, in accordance with their different perceptions of the advantages and disadvantages of parks.

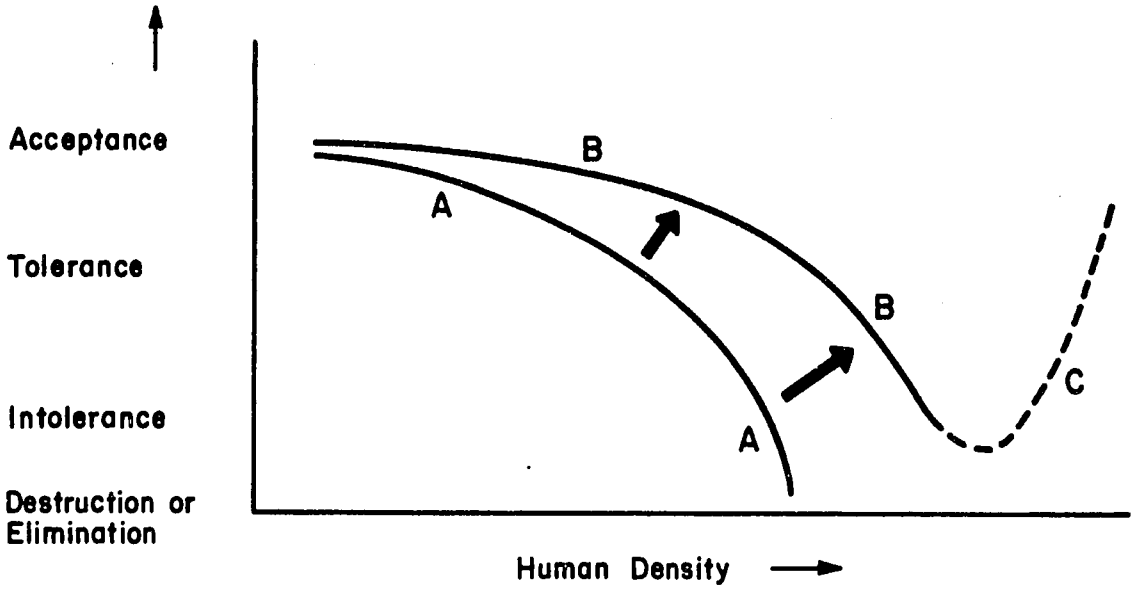

FIGURE 3.1. A representation of the probable relationship between human population density and tolerance of wildlife: AA, the curve where conflict is not ameliorated; BB, the curve where acceptance is kept as high as possible by an accommodating conservation policy. (Policy makers should aim to increase acceptance, ie move the curve from A to B.) C denotes the pattern of human settlement changing with urbanization resulting in a possible increase in the acceptance of wildlife (based on behaviour in Europe and north America, not yet evident in Africa)

EXTERNAL ATTITUDES AND THEIR INFLUENCE ON PROTECTED AREAS

International influences

There is an international dimension to conservation in any country or region, especially with respect to African protected areas. Attitudes and resultant activities on the international scene can, and often do, influence what happens on the ground.

The source of international influence may be any or all of the following:

- Other governments (aid programmes)
- Inter-governmental organizations (UNESCO)
- International conventions (CITES)
- International non-governmental organizations (IUCN)
- The public at large and private organizations (zoological societies, research foundations, etc)

These sources of influence tend to operate in a carrot and stick mode, mostly encouraging or reinforcing positive actions and occasionally opposing actions that work against conservation.

This influence may be either tangible or intangible. Direct aid is the principal tangible influence. It may include cash grants, the supply of

equipment, training facilities, or the provision of experts. However there are complications. The help offered is not always the help wanted. It usually comes with strings attached, from affluent developed societies to poor underdeveloped societies. Too much reliance on international support may confirm local feelings that conservation is largely for outside interests. If a conservation area is of international value the international community should assist in cases of need, but additional benefits can be provided to promote international recognition of the country's conservation efforts, thereby enhancing national prestige.

The anti-killing ethic

Another form of international influence exists in the societies that represent an ethic against the killing of wildlife. In western European cultures the "save wildlife" movement has recently evolved, coincidentally with the increased rarity of wild animals. This has resulted in areas being set aside all over the world for the benefit and propagation of wildlife. Not surprisingly it produces a serious dilemma in the minds of those who contribute towards this conservation effort when, in situations of overabundance, these animals have to be killed.

This anti-killing ethic is a moral issue which stems from the religious or philosophical tenet that all species have the right to life. An extension of this belief is the idea that a park should be a sanctuary for wild species, and harassment as well as killing should be kept to a minimum. Looking at wildlife conservation in these terms emphasises the division in attitudes between the distant, affluent sentimentalists and those who live in direct competition with wildlife. The latter have to accept sacrifices imposed on them by the conservation practice but do not comprehend, let alone accept, such moralising. The solution to the problem is to reduce the conflict as much as possible by emphasising the benefits, if there are any, and educating the people as to the dangers involved in not conserving the area and its resources.

Affection for animals and an aversion to killing them is a deep-rooted and growing sentiment in the western world. The people who share it form a committed block of supporters for conservation, both in financial and in moral and political terms. Pragmatic conservationists must accept that these sentiments are the legitimate beliefs of potential allies and must be handled with sensitivity. It is not necessary to show people colour photographs of bleeding elephants to educate them as to the necessity for culling.

NATIONAL PERCEPTION OF PARK VALUES

Generally the goals set for the management of protected areas are established at a national level, with a view to viding a variety of benefits for the people of a particular country (see Chapter 1). However, not all these goals and associated values will be readily appreciated at the same time by all levels of society. This lack of public appreciation of national policy is an acute problem in Africa where political instability mitigates against the establishment of any long-term

directives. However it can only help to have a country's conservation and development policy clearly defined and widely publicised, as recommended in the World Conservation Strategy. The benefits for conservation that can flow from the public understanding of such a policy, are enormous.

Tourism is an important non-consumptive benefit that is readily recognised by African governments, but is usually of little benefit to local communities. Rural outdoor recreation is valued by only a small, affluent section of society while the majority, particularly lower income people, are indifferent. (In this context subsistence hunting and fishing are not seen as primarily recreational.) However perceptions can change over time. For example, in Swaziland where previously 80% of visitors to Swazi conservation areas were foreigners, the same percentage is today made up of local visitors.

Competition for park resources, particularly land, is the prime source of conflict. The importance of this conflict is often not recognised by governments or their land-use agencies, as population pressures increase in areas adjacent to parks. Many conservation areas are suitable for cultivation or pastoralism which provides a direct remunerative benefit to local people. The sacrifice of foregoing this benefit cannot be compensated for if the financial benefits that result from the conservation of the area's wildlife go directly to central government. The local population must be recompensed either financially (as is being tried in Kenya) or with alternative benefits (employment, education, meat, etc). But this can generate jealousy and antagonism from a misinformed urban public or from the rural poor who live outside the area of wildlife conflict. Thus it can be seen that there are a number of conflicting interests between the various strata of society. While many of the problems generated by such conflict are not the direct concern of wildlife management, park managers should be aware of them and actively endeavour to resolve them.

CONSTRAINTS AT THE LOCAL LEVEL

The factors of greatest importance at the local level are mostly associated with the needs of rising human numbers. These conflicts in the impact zone of the protected area often require solutions that are specific to local circumstances.

Nature conservation in Africa provides many examples of situations where planning has not accounted for the needs of local people, leading to reduced public tolerance of protected areas. Involvement of local communities in defining conservation goals can sometimes change initial antagonism to acceptance. The ultimate achievement is to reach a stage where the local community practices conservation because of the benefits it perceives in such a policy. This section describes how some of the problems have been tackled.

The following case histories show:

a. How similar conservation goals can lead to different results in different situations - montane habitats in East Africa.

b. How an inflexible policy has prevented the utilization of potential resources and maintained negative impacts - Serengeti and Selous Game Reserve in Tanzania.

c. How more flexible policies regarding the availability of resources have led to initial acceptance - Chirisa, Marromeu and Lengwe in central Africa.

Conservation of montane habitats

Aberdare National Park is of national value as a major water catchment for the agricultural heartland of Kenya. It comprises montane moorland surrounded by a buffer zone of forest reserves and then by high density, high yielding peasant farms. These farmers have little requirement for national park resources apart from stream flow, but use the forest areas extensively for timber products. Marsabit Game Reserve, also in Kenya, is of national value in terms of water and resource conservation and is surrounded directly by subsistence level pastoralists and cultivators dependent upon the park's resources - forage, wood and water. Parc des Volcans in Rwanda is a world heritage site due to scenic, geological and faunal values. It is surrounded by very high density peasant small-holdings and land is critically short. People have traditionally used the forest for fuel, timber and cultivation. Locals receive little or no benefit from tourism to any of these three parks.

The Abedare situation is one where the park offers few benefits other than water and is protected by a productive buffer zone. While this situation persists the national park will probably remain acceptable. In Marsabit, local people are deprived of resources and receive little benefit. The park is now under considerable pressure. In Parc des Volcans, population pressures increased to a level where half the park was deproclaimed and made available for agriculture. Since then local education programmes have achieved some success in showing the benefits of water supply and potential tourist revenue.

The case of inflexible legislation

Serengeti National Park and Selous Game Reserve in Tanzania are examples of established, large, unfenced conservation areas. Wildebeest and elephant, the dominant herbivores, frequently move outside their boundaries. Rising numbers of both people and wildlife have caused increased competition as wildebeest invade farms, reduce forage and transmit disease, and elephants cause considerable crop damage. Present legislation permits no compensation for damage and does not allow for the utilization of surplus animals leaving the area. There is therefore, increasing antagonism towards conservation, which people see as causing considerable loss to their livelihood with no legally obtainable benefits.

Apart from any shortage of management skills, solutions to these two cases are complicated by the beliefs and life styles of the local inhabitants. The Serengeti wildebeest could be cropped outside the park but the Masai pastoralists, who are most affected, do not eat venison. Because of this,

and their cattle-based value system, any compensation made available to them (cash, veterinary care, water supplies), would ultimately be converted into more cattle, thereby negating the benefits of wildebeest reduction. International aid generated out of concern for the Serengeti migration phenomenon (its status as a world heritage site has been of assistance in fund raising), could easily end up contributing to a similarly short-term solution. The answer probably lies in a compromise involving buffer zones, the limitation of both wildebeest and cattle numbers and an incentive scheme to provide an alternative, non-conflicting life style for those willing to try it.

Populations bordering the Selous Game Reserve are largely Muslim and do not eat elephant meat. Shooting crop raiders therefore provides no local benefit but does supply government with ivory revenues. Recent suggestions to eradicate elephants in regions away from the Selous, and then to continually crop peripheral groups, would reduce conflict and revenues could go to local projects to show a benefit from the conserved resource.

The economic option

The decision to cull elephants in Chirisa Safari Area, Zimbabwe, led to the formulation of a carefully planned "Operation Windfall". This provided considerable benefits by way of hides and ivory for sale, and inexpensive meat to the local community. In spite of increasing human density, an earlier intolerance of the conservation area by the small and relatively unsophisticated population appears to have changed to one of acceptance. However it is too early to tell whether this goodwill will last, particularly when culling stops or is substantially reduced.

The dense human population adjacent to Lengwe National Park in Malawi was intolerant of the conservation area. An overabundance of nyala within the park resulted in culling, with meat being provided to the local population. This has reduced the intolerance of the park through the provision of benefits, but again it requires time to tell whether the effect is lasting.

Mozambique's conservation project situated in the Maromeu area of the Zambezi river delta, has been accepted by the local populace because they are involved. Prior to independence the area comprised a number of safari hunting concessions and a game reserve. After 1975 they were consolidated into a multiple use area where over 16 000 buffalo have been cropped to date and converted into dried meat, hides and other biproducts for widespread distribution to state enterprises, schools, the military, etc. The local people, who live in communal villages, derive work opportunities from this activity and have spontaneously developed an attitude against poaching and indiscriminate burning. A start has also been made on a freshwater fishery organized on a cooperative basis and other forms of resource use have been planned.

There is a Kenyan example where Masai have been financially compensated for keeping their cattle out of the core areas of the Masai Mara and Amboseli Game Reserves. The cash for this is derived from gate money and distributed through Masai elders. It is an imaginative scheme but open to

corruption and abuse, and may well get overtaken by escalating land use pressure.

In principle these manipulations operate as a trade-off of park resources for some sort of assurance of future security. Yet they will all run the risk of creating a sustained demand or expectancy among local people which later may not be possible to satisfy, and which may then force conservation agencies to overcommit park resources. Policy makers acknowledge from the start that in the long term, most protected areas cannot be expected to sustain material benefits to satisfy the expanding needs of human populations. But this realisation should not be used as an excuse to reject the practice outright. At least the few who suffer major losses could be compensated.

A knowledge of economics will tell the conservation strategist to be wary of attempting to justify the retention of too many wild areas on economic grounds alone. Typically, there is seldom a simple choice between an "economic strategy" or any other, but more likely, a combination of appropriate strategies, with emphasis on non-extractive use in the zone of least conflict or core area. A variety of extractive uses could then be tried in suitable zones, in order to find the most practical and sustainable use of the area as a whole. In this context, extractive use should also be seen as a having potentially great educational value in the field of sustainable use of resources.

Once material values for resources are established for local people they have a chance of evolving towards cultural and aesthetic levels. Cultural values may be intangible but they remain the conservation strategist's strongest and most durable argument for the survival of protected areas. The intent in this respect is the development of a national ethic for land, as is so neatly expressed in the belief, "We have not inherited the earth from our forefathers, we have borrowed it from our children"; probably conservation's most absolute and worthy maxim.

STRATEGIES TO INCREASE ACCEPTANCE OF CONSERVATION

There is a variety of options available to encourage both the appreciation and the wise use of conserved areas. At least some protected areas in any country should be managed in a non-consumptive way (as control zones or ecological bench marks) but there are sound arguments for the consumptive use of some protected natural resources, particularly where these "overflow" from established reserves. It is worth examining some of the strategies available for increasing local acceptance of conservation areas.

General public awareness

Public environmental awareness campaigns, via various communications media and interpretive services, should help develop an aesthetic and cultural appreciation of the value of protected areas. They should also assist an understanding of the ecological problems, such as overabundance, that may be encountered in park management. Target audiences such as politicians, teachers and school children can be selected for meeting specific

objectives. Effort should also be spent on promoting local tourism to offset the current dependence on foreign visitors that exists in many African countries. There is considerable potential in this respect among middle income urban communities in Africa.

Land use planning

These comments are made specifically in respect of land currently occupied by, or in contention with, local indigenous people practicing a more or less traditional life style, usually of a near subsistance level.

In this context land use planning is concerned with two things. It identifies the potential productivity of the land, which is more or less fixed by soils and climate, and the potential of society to manage sustainable production, which can be improved by training, experience and development. Any such plan must therefore be tailor made for the particular rural population concerned and should aim primarily at ensuring self sufficiency in food and domestic fuel supplies. Areas suitable for food and fuel wood production should be defined and allocated to agriculture, having first taken into account the needs for conserving water production and any special sites or biotic communities. Thereafter appropriate uses may be determined for land that should not be cultivated. The latter forms of use should incorporate a strong emphasis on limiting human density and multiple resource use, because sustained productivity in agriculturally marginal regions is likely to be particularly sensitive to poor land-use practices.

The example described by Martin and Taylor (1983) provides a classical case study. They describe a planned mosaic of land uses, in the Sebungwe region of Zimbabwe, from total protection, through utilization by various forms of hunting, to limited agricultural focal points and intensive wild species production units, such as crocodile and fish farms. In this example the principles involved in providing buffer zones to reduce conflict between man and animals, the maximum integration of more or less compatible land uses, and the avoidance of overabundance by cropping animals that naturally disperse from core areas are all well illustrated. This study highlights the need for a sophisticated conceptual approach as well as a high level of skills and material inputs in such a planning process. It also contains an unstated emphasis that the sustained implementation and administration of such plans is no simple matter either, especially in underdeveloped countries.

Legal and administrative procedures

Outside protected areas the development or re-establishment of a land ethic may best be achieved by placing the trusteeship of natural resources in the hands of the local community. The necessary involvement of rural people should be accomplished through their desire to manage their own areas, if possible, helped by sound land use advisory services (see below).

In most rural communities this could not be done without a fairly extended period of consultation and control by such advisory personnel. Integration

of the authority of advisors with that of local leaders is a difficult and slow process, involving periods of gradually shifting responsibility from joint decision making to independent executive authority. In many African situations this process is further complicated by the presence of somewhat cumbersome, centrally controlled, socio-economic systems.

A range of options caters for the sustainable use of natural resources. These include hunting for meat and sport, wildlife harvesting, tourism, the exploitation of the plant resources such as thatching grass, and the limited use of timber and other materials for the manufacture of curios and artefacts. Appropriate rural industries should be established to process these products. Benefits, financial or otherwise, must be returned to the local community, who should be involved as much as possible in the whole process of production, marketing and final allocation of benefits.

Rural education - land use advisory services

The success of the strategies described above is entirely dependent in the long run on educating the users of rural resources. It is probably correctly assumed that the biggest deficit in knowledge and understanding exists on the part of the rural inhabitants. However, there are always misconceptions on the part of administrators and their advisors as to the real needs and attitudes of the man on the ground, and how to weigh these in the balance with other priorities. Advisory or extension services must therefore be seen as two-way processes in which the understanding of the professional advisors as well as the attitudes of local people are continually monitored and assessed.

The role of education in sensible land use and effective conservation is fundamental and long term. It is also worthy of full treatment in a format outside the confines of these brief guidelines. Here it is only possible to deal in generalities. First, the services involved depend on the availability of manpower and skills that are generally absent or grossly inadequate even in developed countries. In underdeveloped countries these shortages are exacerbated by the lack of effective mass communications media, which have proved to be such an effective aid to conservation in the western world. The subject of environmental education or conservation awareness is new and experimental in developed countries, in most of Africa it is hardly acknowledged as having any sort of educational priority. However, there are signs that some people consider the matter important, nearly all of them initiated and funded by conservation interest groups. The successful introduction of wildlife clubs in the schools of Kenya twelve years ago, and more recently in Zambia, and the teacher training programme of the Southern African Wildlife Society in Kwa-Zulu are examples of much needed efforts in this field.

MONITORING SOCIO-POLITICAL ATTITUDES

Monitoring is readily accepted as an integral part of ecological research since it serves to measure the rate and direction of change in the ecological systems being investigated. The same process must be applied to socio-political systems. To monitor the needs and aspirations of local

people and the extent to which their needs are accomodated by conservation planning is an essential step in the integration of a wildlife area with it's local community. But quantifying human needs and expectations is a complex task, outside the expertise of most wildlife managers. It is hoped that conservation authorities will recognise the need for this type of information and obtain the services of sociologists to design and implement necessary programmes.

Data from sociological research would enable the manager to blend more effectively, the goals dictated by the intrinsic value of his area, with the needs of different interest groups wishing to use it's resources. This point deserves emphasis because administrators tend to manage conservation areas only in terms of a mandate defined by urban based or distant (foreign) interest groups. The interests of rural people living near protected areas seldom determine management policy, largely because they lack the necessary channels through which to influence decision makers. Even where management policies have been established by democratic processes, park neighbours will always be a minority group whose problems will be a source of concern.

The argument that the rising tide of humanity will overwhelm all protected areas and conservation efforts, is particularly persuasive in under-developed countries. It is also in these areas that the conservation administrator runs the risk of being accused of callously preferring animals and trees to the well-being of local people. The real value of information from monitoring programmes is that it provides facts about ecological and sociological change over time. It sets the time scale to which conservation activities relate. It supplies projections of trends which often provide the most persuasive arguments for conservation. These should be sufficient to persuade people that the short-term view is selfish and self defeating and that limited hardship is a reasonable price to pay for a greater long-term good.

ENCOURAGING PUBLIC SUPPORT

Protected areas are varied in their make up and consequently cater for a wide variety of "publics". Much of this chapter is devoted to the needs and interests of the "public" closest to, and common to, all such areas, namely the local population. In Africa this usually comprises subsistence level cultivators and pastoralists. The emphasis has been to issue warnings against continuing to underestimate this sector of society and to provide a few indicators as to how to accommodate their needs.

Little mention has been made of the neutral or positively supportive segments of society. These existing or potential supporters of conservation need to be continually informed and encouraged by providing them with interesting facts, discussion and news, and by involving them as much as possible in the whole conservation process. For many of these people, and potentially the public as a whole, protected areas conserve things of real and undisputed value. In acknowledgement of this support and the fact that most protected areas belong to the nation anyway, field management should not proceed in isolation from public opinion. Where this opinion differs from that of conservation managers there is an ideal forum

for public debate and a chance to increase public support. Conservation agencies must not be shy of having to justify their actions to an interested public, most particularly when they are engaged in controversial activities such as culling.

Potential allies for conservation are often highly motivated and vociferous, though of widely differing interests. The majority have a preoccupying interest in animal life but from there the spectrum of supporters can vary from anti-vivisectionists to international safari clubs. Conservation managers may view either end of this spectrum with reserve, sometimes approaching outright disdain. However, it is as well to remember that between, and associated with, these noisy minorities there is a large but mostly silent body of support. It is the beliefs and sensibilities of these supporters that have created the global national park system, it is their contributions whether through taxes, gate money or voluntary funding that pay for the upkeep of protected areas. The conservation administrator or manager must be as sensitive as he can be to this range of public interest, which is usually implemented through the appointment of public relations or interpretive personnel. The callous treatment of a special interest viewpoint will be enhanced by the media if full and considerate reasoning is not provided. In the event of activities such as culling or intentional burning, which have negative impacts on these sensibilities, full and factual explanations are invariably the best policy.

It is worth making brief mention here of the role of the press and the media in general. They can be unforgiving and sometimes unreliable critics of public activity but they can also be an invaluable ally under the right circumstances. One thing is certain, there is no other way of getting conservation interest and information to the public. Education is simply not fast enough. Conservation agencies would be well advised to adopt a positive and outgoing approach towards the media and invest in adequate skilled manpower to give effect to such a policy. The skills involved require, apart form the more obvious attributes, maturity and experience and a position of seniority that allows for direct communication with policy makers within the agency.

IMPLICATIONS OF ALLOCATING PROTECTED AREAS TO SPECIFIC CATEGORIES

Protected areas may be labelled or categorized according to their natural attributes and their conservation objectives. An area may be called a "world heritage site", a "national park" or "national seashore", it may be called a "district game reserve" or "peri-urban recreational area" depending both on its type of public use and the level of authority that administers it. The allocation of each protected area to a nominate category is of most value in identifying to the public the broad style of management and public use that may be practiced within the area. With this in mind, the IUCN has produced a global classification applicable to all national parks and protected areas.

The current nomenclature, which, together with its definitions, may be found in, 1982 United Nations List of National Parks and Protected Areas (IUCN 1982), is as follows:

Category	Name/Designation
I	Scientific Reserves/Strict Nature Reserves
II	National Parks/Provincial Parks
III	Natural Monuments/Natural Landmarks
IV	Nature Conservation Reserves/Managed Nature Reserves/Wildlife Sanctuaries
V	Protected Landscapes
VI	Resource Reserves
VII	Anthropological Reserves/Natural Biotic Areas
VIII	Multiple Use Management Areas/Managed Resource Areas
IX	Biosphere Reserves
X	World Heritage Sites (Natural)

It is a useful exercise for all conservation agencies in Africa to attempt to fit their array of protected areas to the proposed classification system. The benefits of such an exercise are not in whether or not the national and global categories are entirely compatible, that could be of small relevance. The real benefit is in having to provide carefully considered answers to questions such as, "What is the priority order of the objectives for area x?", "What type of management strategy is appropriate for area y?".

Once categorized or named, it is necessary to publicly justify such categorization. This requires specific publicity aimed at informing both the national public and the world at large of the existance of the area, its assets and values, the reasoning behind its allocation of category and the consequences for those wishing to use it and those otherwise affected by its existence. Each category of protected area has what may be termed, socio-economic attributes, as illustrated in Table 3.1.

The gradation of increasing conservation importance (1) is balanced by a reverse scale of decreasing opportunities for multiple resource use (2). For example, a world heritage site of major international significance may permit no use other than the conservation of the ecological components and processes that make the area so valuable. At the other end of the scale, an area of only local conservation value may be so designated merely because it is unsuited to other more intensive forms of land use. Such areas could be regarded as local resource reserves in which a variety of uses could be accommodated under strict control, such as game cropping, collecting fuelwood, cutting thatching grass, bee keeping and even cattle grazing.

As the range of possible benefits to local people decreases (2), so an increase in potential conflict will arise with a parallel increase in demands for compensation (3). The nature and source of any compensation should be state controlled and carefully researched before allocation. Such aid schemes are fraught with potential for misuse and often contain unsuspected negative effects. Where the local economy and infrastructure is totally inadequate to carry out compensatory activities, then the situation deserves international aid or funding. In such cases funding should be channelled to best effect from a conservation point of view. In this context assistance with management, eg culling of surplus animals, may

TABLE 3.1. Relationship between category of protected area and its socio-economic attributes

Category of protected area (determined by type of administration and public use)	Socio-economic attributes		
	(1) Value to conservation	(2) Range of options for alternative uses	(3) Compensation for loss or disturbance
- World heritage site (International conservation communities) - National park (National leadership and governments) - Game or nature reserve (Regional or district administrations) - Recreational area (Local authorities)	↑	↓	↑

provide a more deserving case than compensation for losses incurred by local people.

On the basis of this hierarchy of categories for protected areas and their socio-economic implications, it is evident that there is a need for a thorough review of the status of conservation areas in Africa. Many existing national parks are of no more than regional or even local significance and could easily incorporate some degree of consumptive use that has hitherto been denied. Some protected areas may have to contract in size in the face of expanding human needs for land. This could be accommodated by zoning those areas destined for deproclamation, for some form of multiple resource use. This would help retain a value for the core area as a supply zone for the resources used and would also serve as a buffer against more agricultural forms of land use. However, to end on a positive note there is a more optimistic scenario of the same process. That is, that the use of resources within protected areas should formally be expanded to areas surrounding them, thereby involving local people in long-term utilization schemes which would establish not only a material value for both the resources used and area from which they are replenished, but also an entire cultural way of life that is specifically tailor made to the area's ecological limitations. Dead simple in theory, but, as with "Operation Windfall", the real challenge is in implementation.

IN CONCLUSION

Finally, it must be recognised that socio-economic circumstances are changing with phenomenal speed and often in unpredicted directions. Conservationists may find themselves submerged under a tidal wave of short-term human needs unless they sharpen their awareness of social trends and leave no stone unturned in efforts to devise suitable and innovative long-term strategies. In order to get out of the morbid consideration of ever shrinking protected areas it is time to adopt a more positive and aggressive approach. The export of newly acquired ecological understanding from parks to the areas that surround them is urgently needed. Instead of zoning for multiple resource use only within protected areas, park managers should be promoting multiple resource use outside their borders, where integration with people can be more easily undertaken.

As public leaders all over the world become more informed about conservation issues, there is a slow but growing acceptance of ideas that would have been considered heretical a mere decade ago. But ideas and effort are not enough. A conservation idea will only have "arrived" when it is transformed into accepted practice, which usually requires incorporation into legislation. It is these two aspects of conservation that contain the greatest potential for progress and, of course, for failure between now and the year 2000.

Chapter 4

DECIDING WHAT TO DO AND HOW TO DO IT

Planning, selecting and implementing field management options

Compilation led by
Richard Bell

MANAGEMENT PLANNING

The planning process in field management
The administration of field management

DECIDING ON A MANAGEMENT OPTION

Types of management decisions

THE MANAGEMENT PLAN - STEPS IN THE MANAGEMENT PROCESS

Identification and choice of objectives
Assembly of technical information
Identification of management options
Choice of management options
Implementation of chosen management option
Monitoring and evaluation of performance in relation to objectives
Updating the management plan
Re-evaluation of objectives

ADMINISTRATIVE ASPECTS

Master plans and management plans
The importance of cooperation
A suggested decision making flow chart

USING THE MANAGEMENT PLAN FOR DECISION MAKING

The use of zoning to achieve separate objectives
Using the animal management options key
Management considerations related to overabundance
Minimal intervention or least management

MANAGEMENT PLANNING

The planning process in field management

Management activities generally need to be planned in order to be consistently effective. This sort of planning is a specialised process aimed at providing policy makers with the technical information necessary to make well considered decisions about the future of their protected areas.

Before describing the planning process in more detail there are two important points that must be appreciated.

- Nature conservation is a form of land use where objectives other than short term benefits are emphasised, ie the time scale involved in planning is longer than for other forms of land use.

- In most African ecosystems containing large mammals, ecological and environmental change is inevitable and in some respects desirable. This indicates a need to avoid planning the management of an area for a rigidly described stable state. It is necessary therefore, to plan for this dynamic condition by defining the limits to ecological change that will be permitted, before corrective management action is taken.

A physical product of the planning process is the management plan, the preparation of which involves several basic steps. In practice the information base for planning is invariably inadequate, necessitating the frequent use of assumptions and informed guesswork. This leads to foreshortening of the process, as many of the steps are carried out simultaneously. The following provides a broad framework:

a. Gather and present comprehensive information describing the area and its surroundings, including quantitative data and a description of the dynamics of the system.

b. Consider the practical limitations of money, manpower and expertise and adjacent land use and define the permissible limits to change in the environmental and biological components that exist in the area.

c. Provide projections of future trends and needs, both of the area and its users, and decide on the time span to which the plan relates.

d. Describe the feasible options or courses of action that the above circumstances suggest and evaluate them against the objectives of the area.

e. Select the preferred options of courses of action and present them in a management plan format.

f. Revise the management plan and simultaneously re-evaluate the objectives.

This chapter elaborates on these basic steps by describing the preparation and use of management plans for conserved areas. The existing emphasis towards areas containing large mammal populations is retained.

The administration of field management

A management plan that is not implemented is little more than an interesting academic exercise. To improve its chances of implementation a plan must be more than just feasible and practical and have the support of policy makers. It must also be well adminstered, ie the organizational management of the agency must be adequate.

This involves matters of communication and control between agency functions. It requires sensitivity to the complex relationships between a wide range of staff, from newly graduated scientists through field managers with thirty years experience to groups of unskilled labourers. Administrative procedures must be clearly understood by all staff from middle management upwards. An appropriate starting point in this regard is having a suitable multi-channel administrative structure. The functions of; policy making (which may include personnel, planning and training), administration, management, research and interpretive services (which may include information, education and public relations) require careful integration. This aspect of management is referred to by the general term administration so as to emphasise its distinction from field management.

DECIDING ON A MANAGEMENT OPTION

This section highlights the fact that in all complex land management decisions there are ecological, financial, engineering, legal, administrative and socio-political components that need to be considered. These will vary for each protected area and even more so between different countries, reflecting the characteristic conservation philosophy and policy of each. In practice, these components are often the factors that determine the ultimate choice of management options.

The principles involved in making sound decisions are common to most aspects of management, not just to those in the ecological field. By using overabundance as an example, it is intended to illustrate the two basic components of decision making; the technical component consisting of facts and the preferential component consisting of options. This view of decision making deserves some elaboration.

Types of management decisions

In the context of managing protected areas, the two components of decision making are:

> **Technical decisions:** These are the decisions dealing with questions of fact. The term technical is used in its broadest sense covering the areas of ecology, economics, field management, engineering,

public relations, etc. Technical experts supply the answers to questions such as: What is the state of the system? How can the system be changed?

It is important to recognise that technical predictions are often uncertain, unreliable or inadequate, particularly in the area of ecology and economics. This is because they are both extremely complex sciences in which many of the processes are not fully understood, as much of the necessary information is not available. For this reason, any management system must contain an in-built ability to upgrade our understanding of ecological and economic processes, to test the assumptions on which management is based, to check data, to monitor performance in relation to goals, and to revise the management plan in the light of new information and understanding. In short, the management plan must have a self-correcting capability, in anticipation of technical shortcomings. This means that it must include research, monitoring and plan revision.

Decisions of preference: These are decisions dealing with preferences and opinion, not facts. Nevertheless they are value judgements that are related to facts and are often used to choose between options that, based on facts alone, are of equal merit. For example, they answer such questions as; what state of the system do we prefer? How would we like the system to change?

It is important to be aware of the distinction between these two aspects of decision making, and to realise that most wildlife management questions involve both. A good example is provided by the question:

"Do we have too many animals in this area?"

This requires an answer to two quite different questions:

- What amount of change in the system (ie in terms of animal numbers, habitat, etc) is permissible in this particular area? The answer to this question depends on the objective for the area and ultimately rests on a preference choice.

- Will the number of animals now present (or expected in the future) cause the system to change beyond the permissible limits? This is a purely technical question.

Similarly, a decision to cull because of "overgrazing" or "overabundance" implies that two decisions have been taken. First, the preference decision as to the acceptable limits to "grazing or abundance" and secondly the technical decision that these limits have been exceeded.

THE MANAGEMENT PLAN - STEPS IN THE MANAGEMENT PROCESS

Before considering the steps involved in management it is necessary to briefly discuss the sequence in which they occur.

The preparation and execution of a management plan involves several distinct types of activity, including policy-making, planning and training, field management, research and monitoring. These must be linked together in a logical sequence so that organizational management or administration becomes an integrated process designed to ensure that the actual state of the managed area corresponds to the required state as defined by the chosen objectives.

An outline for an integrated management process is shown in Figure 4.1. This diagram makes the following points:

- Making a decision involves a series of steps and types of activity that are interdependent and in a logical sequence;

- The sequence caters explicitly for inadequate information and for errors of fact and judgement by building into the system the process of correction by trial and error. This is why the flow chart never reaches an end; whichever route you follow, you always return, via monitoring and evaluation, to the choice of goals, the definition of permissible limits to change and to the assessment of the state of the system. In short, the sequence is designed as a self-correcting feedback system.

- Following on from this is the idea that management practices themselves should be regarded as experimental treatments designed to test the ecological theories on which they are based. This emphasises the need for good field management records and for the setting aside of unmanaged control areas where possible, for comparison.

Identification and choice of objectives

Clear objectives are the most important aspect of the management process. They provide the reference point for all debatable decisions and a standard by which changes may be evaluated. This point cannot be over-emphasised. Every time a manager or policy maker is faced with a difficult decision, it helps to ask, "How well does each alternative relate to our overall objective?"

Objectives range from pure conservation involving minimal management, through conservation for specific purposes requiring specific management activities, to exploitation of wildlife resources involving complete manipulation and control.

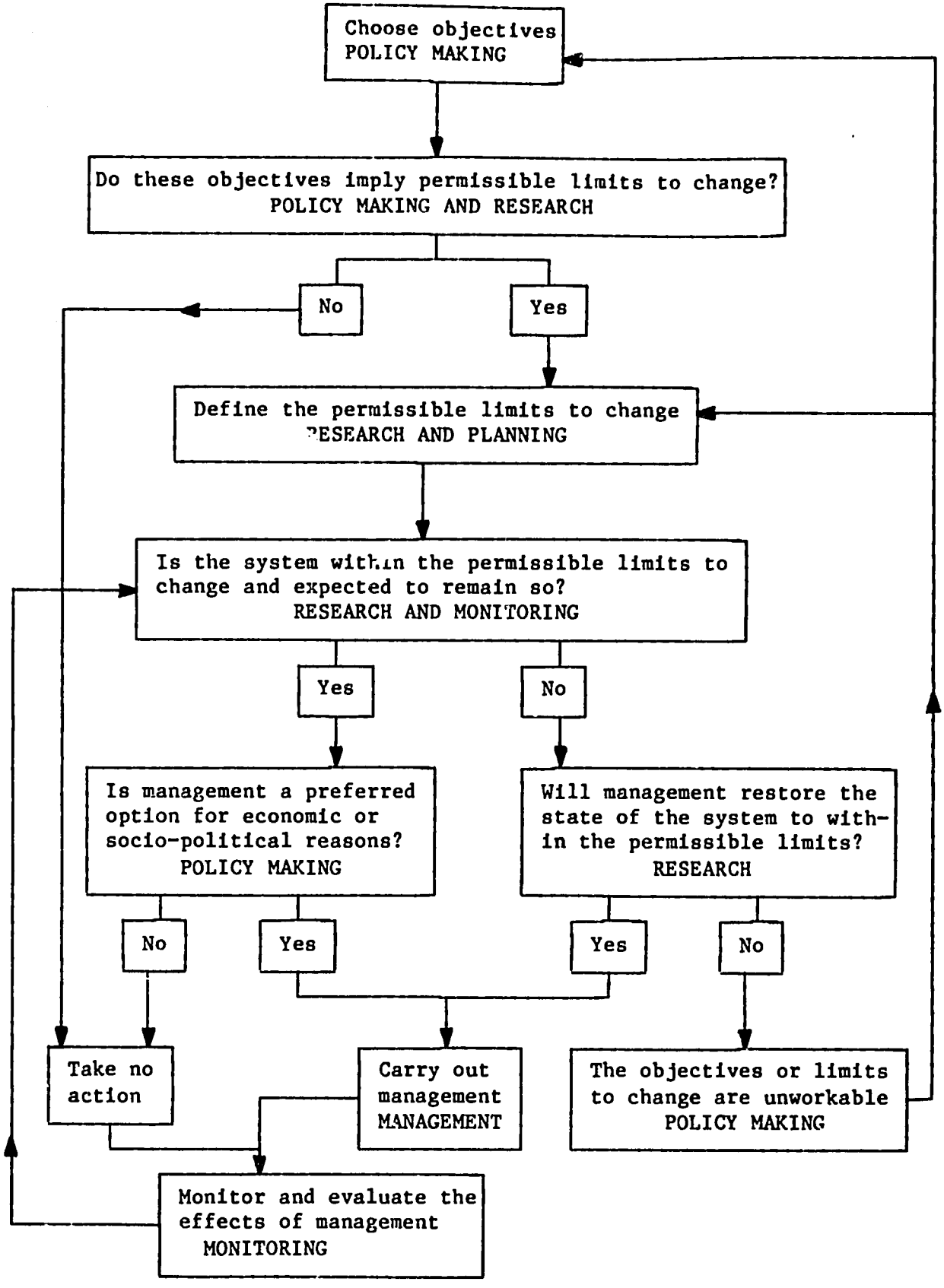

FIGURE 4.1. Flow chart of the logic sequence in the preparation of a management plan

The points to emphasise here are:

a. Objectives must be chosen on the basis of value judgements related to, but not entirely dependent on, the facts of the situation. Ultimately, the choice of objectives is a decision of preference.

b. The character of an area described by technical information, influences the choice of objectives. For example, an area may contain a rare species that is considered important enough to be protected against local extinction. An example is roan antelope in Kruger National Park. In such a case minimal management would be unwise since it is quite likely that this strategy would soon be overridden by detrimental changes requiring corrective management. This example makes the point that choice of objectives must follow the collection of information on the area, and that the objective must be re-evaluated in the light of further information. Scarce information at the start of a conservation enterprise, requires broad initial objectives, initial wide ranging research and subsequent rapid re-evaluation of objectives.

Assembly of technical information

This section covers the gathering of technical information in the areas of ecology, biology, socio-politics, public relations, law enforcement, economics, fund-raising and engineering feasibility, etc. This diverse information is provided from a variety of "technical" sources, such as researchers, managers, professionals and consultants. This demonstrates that there is no clear division between the provinces of research and management and little is gained by trying to emphasise the distinction.

Ecological information: The requirement here is for information on what the ecosystem consists of, how it works, and what changes it is capable of under different conditions. This is a tall order and involves inventory survey, in-depth research, and monitoring of ecological processes. The ecological principles on which such a research programme should be based are set out in Chapter 2. The aspect that directly concerns the policy makers is how to establish research priorities and organize a research programme.

Socio-political information: The vital importance of socio-political considerations to wildlife management has been emphasised in Chapter 3. This affects management planning in that information on these factors must be collected and monitored. It is rare at present for conservation organizations in Africa to make significant progress in this direction, which gives it a high priority rating for the future. However the difficulties of conducting socio-political research in many African situations are fully recognised.

Economic information: The significance of economic information in management planning has been touched on in Chapter 3. The point we wish to stress is the necessity for cost-benefit analysis of all significant management decisions related to land use, conservation

and wildlife management. Economic analysis is specifically concerned with costs and benefits that can be directly converted to money values. It is essential to recognise however, that many costs and benefits cannot be easily measured in monetary terms and therefore tend to be ignored. This is the reason why so many of the world's cultural, aesthetic and ecological values are currently endangered and why conservation actions are now necessary.

One of the main difficulties in cost-benefit analysis is to find satisfactory procedures for comparing monetary and non-monetary values. A method, for use in conservation planning, has recently been proposed by Stauth (1982). This method depends on giving each non-monetary value a rating that can be compared with a monetary value.

The other major problem in economic analysis is in assessing trends of economic values in the long term. This problem has been examined by Krutilla and Fischer (1975). They emphasise that the benefits of technological developments characteristically depreciate with time (ie hydro-electric benefits depreciate because of the finite life of installations and competition from alternative power sources). But the benefits of wilderness areas characteristically appreciate with time (the conservation of wild lands yield increasing benefits because of the increasing scarcity of wilderness areas, and rising incomes which, in turn, raise demand for recreation). Economic analyses must therefore be broadly based to take into account non-monetary values and changes in relative values over a long time scale.

Engineering feasibility: Such feasibility studies are a standard element in management planning. In conservation areas it is particularly important to relate the engineering options, such as road construction, development of water resources and tourist and staff accommodation, to the overall objective of the area in question.

Identification of management options

The identification of management options is the essence of management planning. It involves putting together a series of alternative management packages that are considered likely to achieve the area's objectives, on the basis of the technical information available.

An example is the first stage of planning for the new Lake Malawi National Park. Here the objective to conserve a section of the rocky lake shore of this deep rift valley lake had been identified as a high priority. A survey of the possible areas was carried out and a sector chosen. Three alternative management strategies were presented, each of which was considered capable of meeting the overall objective but in different ways. The first option involved conservation under the existing fisheries and forestry legislation and involved no further intervention. The second option involved the proclamation of a national park to encompass vital areas. This option entailed exclusion of people from certain forest areas

and replacing this resource with fuelwood plantations. The third option involved creation of new legislation to cater for multiple land use, with emphasis on conservation, including installation of fuelwood plantations, agricultural extension and limitations to commercial trawling in a buffer zone.

The main types of option open to wildlife managers in Africa are outlined in Table 4.1. They are arranged in relation to conservation area objectives and the limitations imposed by the key characteristics of each area (these are introduced as "permissible limits to change" earlier in this chapter and included in Tables 4.1 and 4.2).

Choice of management options

The choice of management options is clearly based on a value judgement related to the detailed objectives for the area. This is a management decision that does not involve scientific or technical methods even though research and technical personnel may be party to the decision. Refer also to the decision making flow chart on page 56.

Implementation of the chosen management option

The implementation of the chosen management option is clearly a management prerogative. Although straightforward in principle, implementation must take account of three sets of constraints. First there are administrative and material constraints such as lack of funds, personnel, equipment, skills, etc. Government procedure often involves physical delays that prevent an organization from responding rapidly enough, for example, to avert the effects of unforseen drought, or major equipment breakdown. Recognising these limitations and uncertainties may alter a decision.

The second set of constraints is that there are only a few management tools or methods available. Fire initiation and control, provision of drinking water, animal introduction and removal (culling and capture), vegetation removal and introduction, and erosion control are the more obvious. There are other more specific and often more contentious practices such as application of fertilizer (Kasungu National Park), removal of trees (Sabi Sand Game Reserve), contraception of predators (Etosha National Park), artificial "improvement" of habitat diversity such as providing nesting sites, refuges, provision of food and feeding grounds, and disease control. These specialised practices are not widely available options and should only be considered for achieving very specific objectives.

The third set of constraints is imposed by the lack of certainty that the management option chosen will achieve its intended objective. This is particularly true in the fields of ecology, economics and sociology. Where there is a high degree of uncertainty it is important to design the umplementation of management action so as to learn equally from both success or failure. This means that the management practice must be put into effect as an experiment, with a full set of before-and-after records and the setting aside of control areas where the management action is not carried out but where the same before-and-after records are obtained. Only

in this way can experimental management in valuable protected areas be justified. At least the manager will be able to say that he gained a maximum amount of management knowledge out of the exercise. Neither management nor research can today afford the luxury of inconclusive results that could have been avoided by good record keeping or project planning.

Monitoring and evaluation of performance in relation to objectives

Monitoring is the process by which an organization determines how it is progressing towards its goal. It is the equivalent of navigation in a ship, which compares the actual course and position of the ship with the intended course and position. The information from navigation is used to keep the ship on course or to correct its course if its actual position differs from its intended position. To manage without monitoring is to navigate by dead-reckoning, involving an assumption that we know exactly what we are doing. Monitoring is the information feedback branch of management. It recognises that management is carried out on a basis of uncertainty and must incorporate a continuous capability of testing and correcting itself. Monitoring is also precise measurement, it is the only way of converting that gut feeling about trends or effects into exact numbers, percentages or precise rates of change.

There are several levels at which self correction can take place, which can only be detected by monitoring. To take a simple example, suppose that in a particular park, baobab trees are being destroyed by elephants. We wish to retain a viable population of baobab trees but we do not wish to cull elephants. The research section predicts that, before the baobabs are eliminated, the elephant population will crash and the pressure will be taken off the baobabs. Monitoring shows that the elephants are beginning to crash so we delay the decision to cull elephants. However the elephant population does not crash fast enough, so the baobabs are eliminated. Following the elephant crash we either watch the baobabs regenerate from seed or re-introduce them from elsewhere.

This example tells us three things about monitoring:

- At its first level, monitoring is concerned with the actual state of the system, that is the state of the elephant and baobab populations. Here our knowledge of the state of the system has not lead us to the right prediction of the outcome and we have lost our baobabs. In this case it may be temporary, in another it could be permanent.

- At its second level, monitoring is concerned with our understanding of what the state of the system means. Here monitoring has allowed us to treat our management decision (ie not to cull) as an experiment, with the result that we have learnt something about elephant/baobab interactions that will help us to avoid extinction next time. At this level, monitoring has improved our ability to achieve our goals in the future.

- Monitoring by itself is no substitute for an understanding of the system, but it can help us towards such an understanding.

In protected area management we are concerned with the overall performance of the organization. This includes not only the ecological situation but all aspects of an agency's performance including financial, developmental, organizational, socio-political, public relations, law enforcement, crop protection and engineering aspects. Monitoring is therefore carried out by all types of personnel including ecologists, administrators and field managers. This again shows that the roles of the administrative, management and research staff are of comparable importance.

Let us take law enforcement as an example. Suppose we have a reserve in which an objective is to eliminate illegal activity. Now, the law enforcement branch usually assesses its own performance primarily in terms of periodic reports on expenditure, staff matters and on the number and location of arrests. This type of report, however, does not provide direct information on the questions of primary concern to the organization, which are: How much illegal activity is there in the reserve? and; Are our efforts having any effect on reducing it? This type of reporting is equivalent to steering a ship by means of reports from the purser, the quartermaster, and the engineer, but not from the navigator. It monitors performance in relation to administrative sub-goals, but not in relation to the overall objectives.

The missing information, necessary to relate performance to the overall objective can, in this case, be quite easily supplied by relating the amount of illegal activity encountered to the effort made in detecting it (ie patrol days per unit area etc). This provides a quantitative index of the amount of illegal activity in the area and therefore a means of assessing the effectiveness of the law enforcement effort. It allows the organization to respond to changes in the amount and distribution of illegal activity by changing the amount, type and distribution of law enforcement effort. This method is equivalent to the catch-per-unit-effort approach used by marine fisheries.

In summary, monitoring should be carried out in all branches of the organization, ie:

a. Ecological or research monitoring: This is covered in Chapter 5.

b. Monitoring of field management performance: data collection and reporting systems must be designed to monitor field management activities in relation to their goals, ie

- game removal programmes must be monitored in relation to: their effect on vegetation if they are carried out for habitat control; profit margin if they are carried out for economic return; and their public relations impact if they are carried out for socio-political reasons;

- law enforcement programmes must be monitored for their effect on the rate and extent of illegal activity;

- crop protection efforts must be monitored for their effect and the cost-effectiveness of protection measures on the rate of crop damage, and their effect on public opinion;

- education programmes must be monitored for their effect on changes in public opinion and the extent of awareness;

- tourist developments must be monitored for their effects on tourist flows, public relations and economic return;

- financial expenditure must be monitored in relation to implementation of the work programme.

c. Administrative monitoring - measurement of the efficiency with which administrative functions, including planning and training, meet the needs of the management and research sections.

Updating the management plan

This step completes the self-correcting process by which the performance of the organization is redirected towards its objectives if monitoring shows that progress is too slow or misdirected.

Most organizations specify a definite period after which management plans should be reviewed and revised, ie three or five years. It is of course a necessary feature that a maximum interval between reviews should be fixed, so the management plan does not become outdated. However, if the need arises, the plan should be revised more frequently, and in complex organizations, the plan should be regarded as being under continual review.

Re-evaluation of objectives

The final step of the integrated management process is the re-evaluation of goals. This may take place at two levels:

First, technical information may show us that our various goals, which are usually in order of priority, may be technically incompatible. For instance, the public reaction against the loss of baobabs, in the elephant/baobab example, may prove so strong that in the interests of retaining public support, we may have to modify our goals to ensure the survival of baobabs. Here technical information on ecological interactions and public attitudes has shown us that the strategy of non-interference is incompatible with our primary goal of maintaining all elements of the park.

The second level at which goals may be re-evaluated is at the level of a change in the value system by which goals are established. For example, the original goal for a conservation area may be to maximise revenue from tourism. However it may appear that the development of tourism is having a detrimental effect on the area, so policy makers rearrange the order of priority, giving precedence to conservation and halting or slowing down tourist development. Here the re-evaluation of goals has been brought about by an aesthetic re-appraisal of the relative value of tourist revenue and wilderness quality; a decision of preference.

ADMINISTRATIVE ASPECTS

This section is concerned with the organizational management or administration of a conservation agency. The essential features of such a task are, first, that it can identify and select appropriate objectives, and secondly that it can work realistically towards achieving those objectives.

For the first requirement the agency must function as an integral component of overall government administration. Because conservation interacts with other forms of land use at the regional level and has many cultural implications, conservation departments must develop channels of communication with decision makers in a wide range of interest groups. Within governments it is desirable to establish inter-ministerial and inter-departmental committees, so that any developments with significant environmental implications can be discussed. Environmental impact assessments can then be initiated and conflicting interests, usually between short-term economic interests and environmental considerations, can be resolved. On a broader cultural basis many conservation agencies are responsible to a Board (either advisory or executive) made up of influential members of society who can appraise the broader ecological, economic and political implications of the more important issues. In essence, both the inter-ministerial committees and the Boards personify the value systems of the national leadership by which the primary objectives of the conservation department are set.

For the second requirement (an ability to work effectively towards objectives) the size and complexity of the organization will depend upon the scope of its responsibilities and its funding. However it will usually require staff trained in a variety of disciplines including field management, research, planning, administration and public relations. The essence of good organizational management is to establish a system of hierarchic responsibility and communication that allows the members of the organization to relate their immediate function and goals to the objectives of the organization as a whole. This can be done by developing an overall master plan for the organization into which the management plan for each area or section is integrated.

Master plans and management plans

The master plan for a conservation organization is essentially a summary and synthesis of all the component management plans and as such has two functions:

- To present the objectives, methods and requirements of the organization to other government agencies, the Board, funding bodies, the public, etc.

- To define the responsibilities and performance required of the interactive components of the organization at each level.

The master plan and the management plan for each component (ie park, reserve, specialist branch) should be drawn up by a team ideally comprising a planning officer and the appropriate management, research and specialist staff. The compilation of management plans for conservation areas or functions must involve at least the senior personnel manning the area or function. This is a vital component of staff job satisfaction and provides the necessary two-way communication between policy makers and managers. After preliminary planning, policy makers from other regional land-use functions such as agriculture, irrigation, transport, etc, should be involved. Meetings should be convened to settle differences of opinion and achieve overall agreement on the plans by compromise if necessary. Final approval is of course, the responsibility of the head of the organization concerned.

The master plan and its component management plans become the principal working documents for the conservation organization and its various branches. As the range of management options is stated, and the personnel involved in decision making and implementation are defined, conflict situations involving different branches, particularly research and management branches, should be minimised.

The importance of cooperation

An overriding consideration in compiling and implementing the master plan and its component management plans is that it should be a cooperative effort involving all branches of the organization, including field staff, researchers, planners, interpretive staff and administrators.

As described earlier in this chapter, management is an integrated process involving a series of steps linked in a logical, interlocking sequence. At the end of the sequence there is monitoring and evaluation of performance in relation to objectives. This gives the organization the capability of self-correction and improvement, ie, adaptation and evolution in a changing environment: a controlled system of trial and error - like nature.

It is important that any aspect of management, such as culling, burning, bush control, road positioning, siting buildings, etc which might have ecological implications should be agreed upon by both management and research staff prior to implementation. Arbitration by higher authority may be necessary when agreement is not achieved but, in this case, a note of warning should be sounded. Compromise decisions, or give-and-take agreements, often stand a smaller chance of achieving the objective than do either of the widely differing alternatives. A hypothetical example:

A manager recommends culling 1 000 wildebeest from an overgrazed, fenced reserve in order to avoid bush encroachment. A research officer predicts that natural regulatory processes will make culling unnecessary. The arbitrator cannot decide on either and suggests that a compromise figure of 500 wildebeest be removed. This has the effect of stabilizing the population at a high level thereby ensuring continued overgrazing and probable bush encroachment, and nobody is any the wiser. The compromise decision had no chance of success, but each of the opposing policies had some chance, albeit only that of knowing what not to do next time!

Close and frequent contact between research and management staff in a reserve is likely to result in a feeling of mutual understanding and cooperation. This tends to promote convergence of views which creates a solid foundation for any proposals forwarded for approval. The efficient and effective functioning of an organization depends, in no small measure, on such cooperation at a grass roots level.

A suggested decision making flow chart

The flow chart illustrated in Figure 4.2 represents an ideal decision making process. It is not the only ideal process as these will vary from agency to agency depending on the extent of delegation of responsibility. However the process is based on the assumption that the agency is entirely competent, logistically, to deal with any problem to which the flow chart may relate.

USING THE MANAGEMENT PLAN FOR DECISION MAKING

The use of zoning to achieve separate objectives

When managing for multiple and sometimes conflicting objectives the best way of achieving them all within the same area is by using separate zones. These zones must be selected on the basis of ecological suitability and on practical issues such as their potential for development, use and accessibility. Where the protected area is large enough the zoning system may permit: ecological control zones (minimal management); rare species refuges (very specific management); "gape-points" where visitor facilities and high animal concentrations create "ecologically sacrificed" focal points, such as at artificially maintained salt licks and water holes.

Using the animal management options key

Table 4.1 displays a selection of conservation objectives (1-8) together with a selection of permissible limits to change (A-G) as discussed earlier. The lists are neither detailed nor exhaustive but the resultant matrix does provide a simple means of indicating general approaches to field management under a wide variety of circumstances.

Table 4.2 provides a step-by-step question and answer key by which the necessity or desirability to reduce an animal population may be determined. It uses the sets of objectives and the permissible limits to change displayed in Table 4.1. The use of these tables may best be illustrated by means of examples or case studies with three different objectives: whole community conservation; conservation for productivity; species preservation.

Whole community conservation: The objective of many of the larger conservation areas in Africa is "whole community conservation", although it is often not stated. The actual degree of management practiced will depend on the characteristics of the zones within the area, the specification of the permissible limits to change within each zone, and the resources of the conservation agency. Objectives 2, 3, 5, 6 and 8 in Table 4.1 are relevant

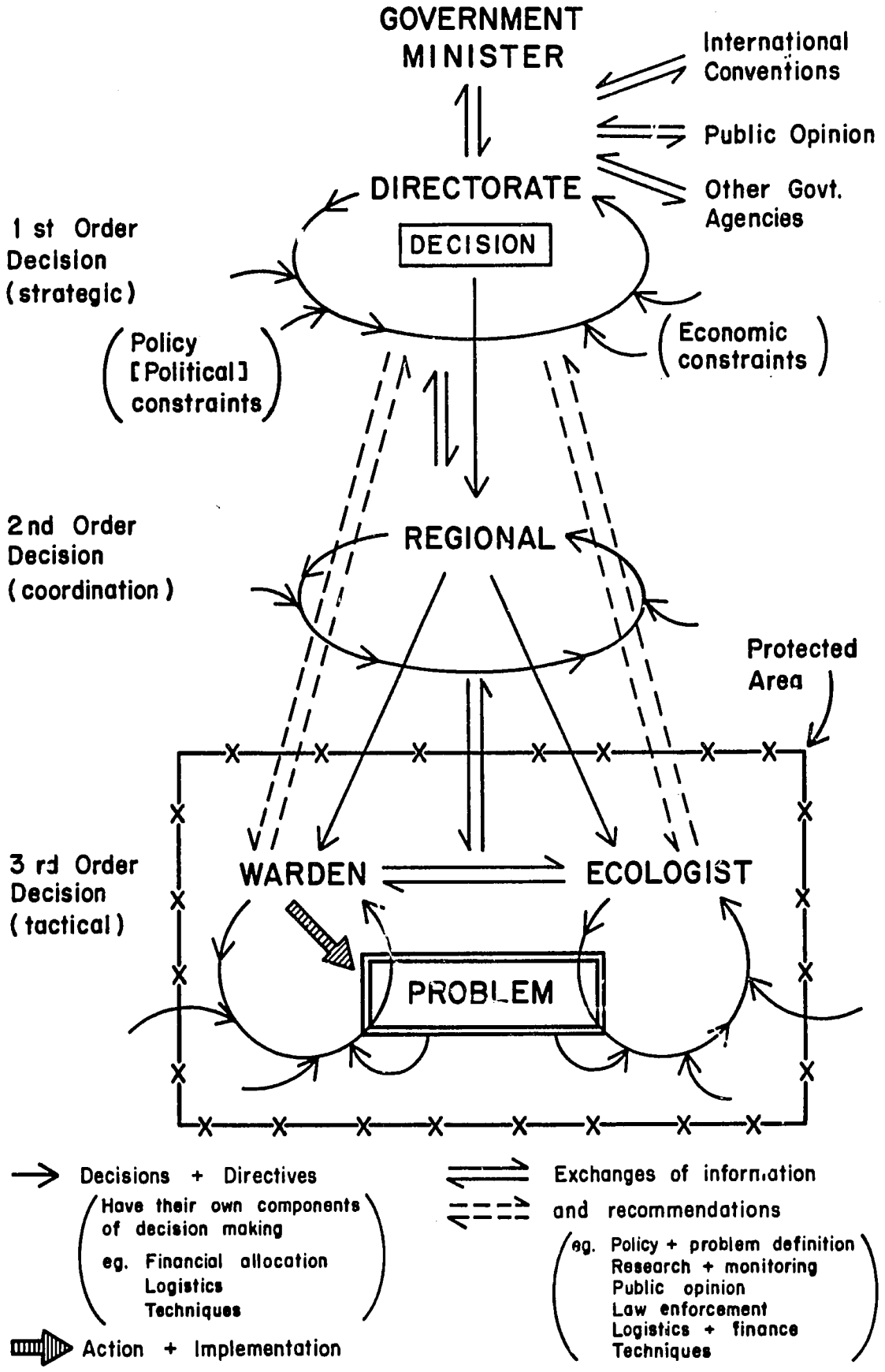

FIGURE 4.2. A hypothetical flow chart for decision making within a nature conservation agency

to this type of approach. The Kalahari Gemsbok National Park and most zones of the Kruger National Park serve as good examples. The permissible limits listed in the column under objective 2 can be studied to ascertain management priorities, ie no species must be allowed to become extinct or to fall to very low numbers. Only specified, limited amounts of vegetation change, soil erosion, illegal offtake and development (roads, buildings, etc) are permissible and financial expenditure must be kept to a minimum. If we now test our objective against the animal management options key in a practical example (such as for the Kalahari Gemsbok National Park) the sequence will be as follows:

Q1: What is the objective for the area? Answer: Conservation of whole communities.

Q2: Does the objective imply permissible limits to change? Answer: Yes.

Q3: Define these limits: They are defined in factors A to G in Table 4.1.

Q4: Are the defined limits practicable and mutually compatible? Answer: Yes.

Q5: Is the state of the system now within the acceptable limits, and expected to remain so? Answer: Yes.

Q15: Is culling a possible option if the state of the system is within the permissible limits and expected to remain so? Answer: No.

Q16: Are there alternative management options if the state of the system is within the permissible limits and expected to remain so? Answer: No.

Q26: - Answer: Take no action - MONITOR!!

Q5: - Is the state of the system now within the permissible limits and expected to remain so?

As a second example, we could test the case of the Kruger National Park against the management option key, the sequence will be as follows:

Q1: What is the objective for the area? Answer: Conservation of whole communities.

Q2: Does the objective imply permissible limits to change? Answer: Yes.

Q3: Define permissible limits to change: They are defined by factors A to G, Table 4.1

Q4: Are the defined limits practicable and mutually compatible? Answer: Yes.

Q5: Is the state of the system now within the permissible limits and expected to remain so? Answer: No.

Q6: Is the size of one or more animal populations a contributory factor in causing the system to change beyond the permissible limits? Answer: Yes, elephant, buffalo and hippo populations.

Q7: Is culling a possible practical option if the state of the system has changed or is expected to change beyond the permissible limits? Answer: Yes.

Q9: Has culling already been found to be ineffective in restoring the system to within the permissible limits? Answer: No.

Q10: Will culling restore the state of the system to within the permissible limits? Answer: Yes.

Q11: Calculate the offtake.

Q12: Will culling at this level cause a public reaction that will make achievement of the objective difficult or impossible? Answer: Yes.

Q13: Will increased public education about wildlife population control improve its acceptability? Answer: Yes, therefore initiate public relations/education programmes.

Q12: Will culling at this level now be unacceptable to the public? Answer: No.

Q14: Is culling at this level practicable in terms of logistics, costs, expertise and control? Answer: Yes.

Q28: Therefore cull and MONITOR.

Q5: Is the state of the system now within the permissible limits and expected to remain so?

Conservation for productivity: This time we take for our example, a game ranch intending to produce live animals, trophies, meat, hides and other by-products for profit. The management strategy would probably be to base productivity on a set number of suitable species, either eliminating competitors (eg predators) or letting them fend for themselves without management assistance (eg herbivores of little economic importance). In the case of objective number 8 (Table 4.1, retention of land-use options) the "nil extinction" limitation would probably override these latter conditions.

The question sequence follows the previous example and the key in Table 4.2:

Q1: What is the objective for the area? Answer: The generation of revenue by production of meat and other saleable commodities within a broad "good conservation" framework.

Q2: Answer: Yes.

Q3: Answer: Factors A to G as per column 7 in Table 4.1.

Q4: Answer: Yes.

Q5: Answer: Yes.

Q15: Answer: Yes, as set by sustainable yield quotas.

Q20: Is removal a preferred option? Answer: Yes, for sport hunting and meat production.

Q21: Has removal already been tried and found to cause changes beyond the permissible limits? Answer: No. If there are unacceptable changes then the permissible limits or objectives must be re-evaluated.

Q22: Calculate maximum offtake.

Q23: Will cropping to this level cause a public reaction that will make achievement of objective difficult or impossible? Answer: No.

Q24: Will cropping to this level be practicable in terms of logistics, costs, expertise and control. Answer: Yes.

Q28: Crop calculated off-take.

Q5: Evaluate the effects of the off-take annually in terms of the objectives and decide whether the system is still within the permissible limits. This is the monitoring action necessary to evaluate whether the economics of the enterprise are sustainable ecologically.

Species preservation and propagation: Our example is the Bontebok National Park in the Cape Province, the objective of which is to preserve the bontebok and establish a breeding herd to produce sufficient animals for introduction into other parks and eventually to private land in its former range.

The question sequence again follows the previous examples.

Q1: Answer: As above, column 4, Table 4.1.

Q2: Answer: Yes.

Q3: Answer: Factors A to G in column 4, Table 4.1.

Q4: Answer: Yes.

Q5: Answer: No, because the recruitment rate has decreased in recent years as a result of the effects of an excessive number of males.

Q6: Answer: Yes, for the same reasons as above.

Q7: Is removal a possible/practical option if the state of the system has changed or is expected to change beyond the permissible limits? Answer: Yes, by live capture and redistribution of breeding nuclei, and if there is no demand for excess live males they may be culled. Similar strategy for any other species that have a deleterious effect on bontebok.

Q9: Answer: No.

Q10: Answer: Yes.

Q11: Calculate the off-take.

Q12: Answer: No, due to practice of live translocation.

Q14: Answer: Yes.

Q28: Proceed with translocation or culling of males.

Q5: Answer: To be obtained by ongoing monitoring of the bontebok population.

Management considerations related to overabundance

In previous chapters a range of objectives and strategies for conservation has been outlined in broad terms. Most deal either directly or indirectly with problems of overabundance, however there are some additional, more specific points worth mentioning.

The most obvious way to overcome an overabundance problem is to reduce the number of animals by either live capture or killing. If the first option is feasible, the interests of conservation are served by restocking appropriate areas. Where this option is not feasible, the wildlife manager should have an opportunity to sell the products of any cull and obtain a financial return for his conservation efforts. Certain administrative systems do not allow for this feedback of funds. Where there is a potential for excessive exploitation this is a good thing. Where this potential does not exist it is a hindrance to conservation progress.

Once the decision has been taken to reduce an animal population, all relevant information should be carefully analysed to determine the best strategy. First the precise cause and effect must be established in respect of the particular limit to change that is about to be exceeded (eg

tree damage) so that the culling remedy can be specific (eg cull only young adult male elephants). Once the strategy has been decided upon (eg culling young males only in areas of damage when damage is taking place) the manager must be aware of unexpected side effects (eg on population breeding rate) and design a monitoring programme accordingly.

There are many reasons why a deliberate removal operation may not be feasible; lack of money, equipment or expertise, veterinary restrictions and lack of markets may all play their part. Other options to relieve the problems of overabundance which do not necessitate removal of animals should therefore also be considered.

Through the judicious use of fire and the supply of water points, a more widespread distribution may be achieved which could effectively raise the carrying capacity of the area. The artifical creation of suitable habitats by manipulating the vegetation (eg by mechanical means such as mowing, tree thinning, fertilizing) may be expected to have similar effects. Some of these are radical management options with limited or temporary chances of success. They should be aimed only at specific objectives and considered very carefully before implementation.

Minimal intervention or least management

The ideal of many conservationists and wildlife managers is to set up and maintain a situation which they feel is as close to being "natural" as possible. But what do we mean by "natural" and how far will we allow "natural" processes to continue if they seem to be producing results that conflict with our goals?

The problem lies in the fact that it is difficult to define the term "natural" in such a way that we can really use it. For example, if we define as natural those situations that are not affected by man then no area on earth can be considered natural. Or, if we define as natural those situations not affected by modern/technological man then we involve ourselves in an arbitary definition of, "when is modern?" and "what is technological?". Finally if we include all human affairs within the definition of natural (a perfectly valid use of the English word) then the term has no relevance to conservation.

For this reason the term "natural" is of limited value in discussing wildlife management issues, other than to strike a contrast in general terms with "cultured" or "man-made".

The term minimal intervention applies to situations where the objective is to reduce, as much as possible, the impact of man on the environment. A strategy of minimal intervention has several points to recommend it in conservation areas, especially where economic considerations are of minor importance. These points have been touched on in the chapters on objectives and concepts, but deserve a little elaboration.

The first point, which has been emphasised repeatedly in this manual, is that our understanding of ecosystem processes is at best inadequate, so any form of management is likely to produce unexpected and often undesirable

side effects. For example, as Soulé and Frankel (1980) have pointed out, culling of elephants by clans may have the effect of eliminating rare gene complexes from the population. This possibility is now known but, as Sinclair (1983) has emphasised, there are any number of possibilities of which we are not yet aware.

The second point, which relates to the first, is that areas of minimal intervention, in which ecosystem processes are allowed to proceed without manipulation, can allow us to improve our understanding of those processes by acting as "natural" laboratories and control zones against which the behaviour of manipulated ecosystems can be compared.

The third point, which has been emphasised by Walker (1983), is that manipulation of ecosystems can reduce their resilience and cause them to rely more heavily on continual manipulation in the future. Walker's example is that the resilience of an ecosystem may be dependent on the presence of unpalatable plant species. These species in turn depend for their survival on periodic bouts of very heavy grazing by herbivores. If these bouts are eliminated by culling, the unpalatable plant species disappear and the ecosystem becomes vulnerable to total collapse if culling is suspended or a major drought occurs. Intervention therefore will breed the need for further intervention; instead of encouraging the ecosystem to develop and maintain its own resilience, it may create an invalid in need of permanent attention.

TABLE 4.1. Relationships between a selection of possible objectives and the permissible limits to change

Objectives / Permissible limits to :	1. Total conservation or ecosystem conservation:- scientific control zone, traditional no-go area, wilderness area, etc	2. Conservation of whole communities - within specified limits:- National Park, nature reserve, game reserve, etc	3. Preservation of particular landscape features or parts of communities:- migration route, tidal marsh, thermal spring, etc	4. Genetic conservation of a particular species or group of species:- species reserve, botanic reserve, etc	5. Conservation for human use, recreation, education, research, cultural and aesthetic enjoyment:- resource reserves, interpretive areas, etc	6. Conservation of watersheds for sustained production of fresh water and soil erosion control :- mountain chains, wetlands, river systems, etc	7. Conservation for productivity of food and other products or by-products (eg trophies) for cash:- controlled hunting areas, game ranches, etc	8. Conservation to retain options for future land use:- any form of land use in keeping with the limits specified below
A. Plant or animal extinctions	No limit	Nil	No limit except for those set by specific objectives (key species)	No limit except for key species	Exclusion of species incompatible with particular form of human use	No limit except where it affects primary objective	Array of species determined by economic and management factors	Nil
B. Gross change in populations, especially towards rarity	No limit	Minimum	No limit except for those set by specific objectives (key species)	No limit except for key species	Minimal limits Specified amounts determined by key uses	No limit except where it affects primary objective	No limit - except where set by economic and management factors	Minimum
C. Gross vegetation change, especially loss of biomass	No limit	Specified amounts (small) according to secondary objectives	Limits set by specific objectives (key features)	Limits set by needs of key species	Minimal limits Specified amounts determined by key uses	Strict limits set by primary objective	No limit - except where set by economic and management factors	Minimum
D. Loss of soil and nutrients	No limit	Specified amounts or minimum	Limits set by specific objectives (key features)	Minimal within limits set by key species	Minimal limits Specified amounts determined by key uses	Strict limits set by primary objective	Minimum within constraints of maximum productivity and good conservation	Minimum
E. Human access and use of resources, including uncontrolled use, eg grazing	Limits specified by secondary objectives	Specified amounts or minimum	Minimal limits set by secondary objectives (key features)	Limits specified by needs of key species - others no limits	Generally maximum within the limits set by key uses	Minimal limits except where conflicting with primary objective	Limits set by cost/benefit analysis and management style	Limits set by objectives of interim form of land use
F. Development - roads, buildings, fencing, water, etc	Minimum for administration only	Specified amounts (small) according to secondary objectives	Minimum according to secondary objectives	Limits (not necessarily small) specified by key species	Limits set by key uses	Minimal - restricted to serving major objectives only	Limits set by cost/benefit analysis	Minimum and impermanent where practical
G. Financial expenditure needed to achieve goals	Minimum for administration only	Sufficient to achieve objectives	Minimum to achieve specific objectives	Sufficient to achieve primary objective	Adequate to achieve optimum human use of area	Minimum - except in support of primary goals, eg reservoirs	Precise limits set by profitability and management style	Minimum, but limits set by interim form of land use

TABLE 4.2. A key for determining animal population management options (after Bell in prep)

Notation: P = Preference decision T = Technical decision M = Management action

		QUESTION	Go To
1	P	What is the objective for the area? (refer Chapter 1 or Table 4.1).....	2
2	P	Does the objective imply permissible limits to change?...YES	3
		NO	26
3	P	Define permissible limits to change (refer Table 4.1, A-G)..	4
4	T	Are the defined limits practicable and compatible?.....YES	5
		NO	3
5	T	Is the state of the system now within the permissible limits and expected to remain so?.....YES	15
		NO	6
6	T	Is the size of one or more animal populations a contributory factor in causing the system to change beyond the permissible limits?.....YES (Overpopulation problem)	7
		NO	8
7	P	Is removal a possible and/or practical option if the state of the system has changed or is expected to change beyond the permissible limits?.....YES	9
		NO	8
8	T	Are there any practicable alternative management options that will restore the state of the system to within the permissible limits?.....YES	27
		NO	25
9	T	Has removal already been found to be ineffective in restoring the system to within the permissible limits?...YES	8
		NO	10
10	T	Will removal restore the state of the system to within the permissible limits?.....YES	11
		NO	8
11	T	Calculate the offtake required to restore the system to within the permissible limits.....	12
12		Will removal at this level cause a public reaction that will make achievement of objective difficult or impossible?.....YES	13
		NO	14
13		Will increased public education about wildlife population control improve the understanding of this management option to make it acceptable?.....YES	12
		NO	8

14	T	Is removal at this level practicable in terms of logistics, costs, expertise and control?.....YES	28
		NO	25
15	P	Is removal a possible option if the state of the system is within the permissible limits and expected to remain so? YES	20
		NO	16
16	P	Are there alternative management options if the state of the system is within the permissible limits and expected to remain so?.....YES	17
		NO	26
17	P	Are any alternative management options preferred in this situation?.....YES	18
		NO	26
18	T	Have alternative management options been tried and found to cause changes beyond the permissible limits?.....YES	26
		NO	19
19	T	Will alternative management options cause changes beyond the permissible limits?.....YES	26
		NO	27
20	P	Is removal a preferred option if the state of the system is, and is expected to remain, within the limits i.e. for revenue, sporthunting, species protection, etc.....YES	21
		NO	16
21	T	Has removal already been tried and found to cause changes beyond the permissible limits?.....YES	16
		NO	22
22	T	Calculate maximum offtake that will not cause change beyond the permissible limits.....	23
23		Will this level of offtake cause a public reaction that will make achievement of the objective difficult or impossible?.....YES	16
		NO	24
24	T	Will this level of offtake be practicable in terms of logistics, costs, expertise and control?.....YES	28
		NO	16
25		Objective is not attainable; objective and/or permissible limits must be redefined, review POLICY.....	1
26	M	Take no action and continue MONITORING.....	5
27	M	Carry out alternative management options and MONITOR.....	5
28	M	Remove and MONITOR.....	5

Chapter 5

WHAT CAUSES CHANGE? - GETTING AT THE FACTS

The role of ecological monitoring

Compilation led by
Ian Macdonald and Jeremy Grimsdell

MONITORING RELATIVE TO RESEARCH

HOW MONITORING DEPENDS ON MANAGEMENT STRATEGY

A FRAMEWORK FOR DEVELOPING A MONITORING SYSTEM

- Baseline survey
- Detecting changes over time - the role of an ecosystem model in designing a monitoring programme
- Logistical limitations to monitoring
- Initial monitoring
- First evaluation

COMPONENTS OF A MONITORING SYSTEM

- Frequency
- Scale
- Sampling - the accuracy and precision of estimates
- Ecosystem components that require monitoring

METHODS OF MEASURING COMPONENTS

ORGANIZATION OF INFORMATION FROM A MONITORING SYSTEM

- Storage and checking
- Information flow
- Analysis and interpretation

THE NEED FOR REGULAR RE-EVALUATION

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MONITORING RELATIVE TO RESEARCH

In all reserves regardless of how much management takes place it is necessary to be aware of the ecological processes operating in the area and the direction and rates of the changes that occur. Management is often carried out on the basis of a few facts and a lot of assumptions.

Research is conducted in order to increase our understanding of the ecological components and processes of ecosystems, whereas monitoring is the procedure developed to measure the direction and rate of these processes. It is important to remember that both these activities are interdependent and contribute to the same end. Research is often a short-term (eg 5 years), in-depth investigation carried out to test a hypothesis and is usually conducted by trained scientists. It may or may not be directly relevant to management objectives, but in the long term is essential for testing the assumptions on which most of our current management is based.

Monitoring on the other hand is directly related to the objectives of the reserve. It provides information which is to be used to help manage the area and is designed with that in mind. It is long term and repetitive. Monitoring systems are designed and initiated by scientists but not necessarily carried out by them. The scientists who are responsible for a monitoring programme must ensure that those who gather the data understand why they are doing so. While a researcher may have no further use for his data once the research project is terminated, in monitoring the older the data the more valuable they are, and their long-term security is a major concern. This chapter will mainly be of value to management and research scientists, but it is written in such a way, and in the sincere hope, that it will help explain the value of monitoring to all interested field management personnel.

HOW MONITORING DEPENDS ON MANAGEMENT STRATEGY

The type of monitoring programme suitable for a protected area is determined by the objectives of that area. While many different goals have been identified (Chapter 1), there are three basic approaches or strategies available to reserve management which influence monitoring.

Minimal management

Control or base-line areas, where interference with ecological processes is minimal, have a primary goal of providing a reference point against which the changes observed in managed systems can be measured. As a consequence adequate and, in particular, long-term monitoring of ecological processes in these reserves is absolutely essential.

Management for ecological objectives

Where management is carried out to maintain a particular component or characteristic of a system, such as a particular array of species or a successional vegetation type, monitoring should concentrate on the factors that have a direct bearing on that component. Data collection should be sensitive enough to provide a feedback of information for management so that the system may be maintained within acceptable limits. The monitoring system must ensure that the information is gathered both before and after the management action and in control areas to enable the true effect of the management action to be clearly identified.

Management for economic objectives

Where the area is managed for an economic objective such as outdoor recreation or meat production, ecological processes can be monitored in less detail. Data collection must provide sufficient information on the parts of the system that are being exploited, to provide feedback on the management actions and how they relate to the costs or benefits of the exploitation. In addition there must be sufficient monitoring of the specific ecological processes that relate to the resource being used, to ensure its long-term sustainability.

A FRAMEWORK FOR DEVELOPING A MONITORING SYSTEM

It is important to realize from the outset that an ideal or even functional monitoring system cannot be achieved in one step. A framework for initiating a monitoring system and then improving it in the light of experience is suggested below.

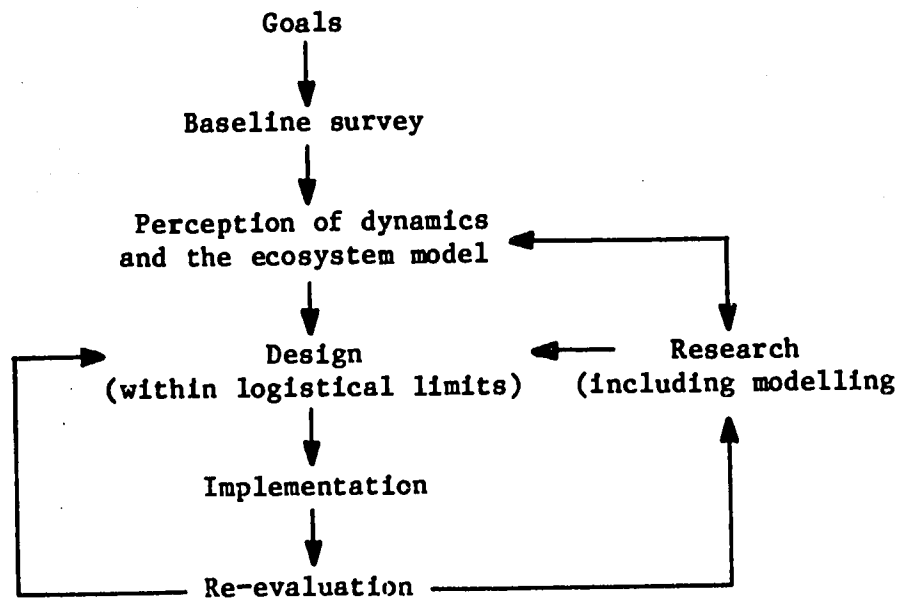

FIGURE 5.1. A framework for the development of a monitoring system

The framework, as depicted in the flow diagram, starts with the reserve's goals and all steps in the diagram are guided by those goals. A baseline survey, together with preliminary research lead to an initial design which is then implemented. This design is updated periodically on the basis of further research and re-evaluation. In this section all steps in the design process, except for actual implementation, are described. Implementation of the monitoring programme is discussed in subsequent sections of this chapter.

Baseline survey

In areas where little or no ecological survey has been conducted, a baseline of ecological data and understanding must be established before a routine monitoring programme can begin. A baseline survey is typically short (say 2-3 years) and should be aimed at collecting information on a wide range of ecological attributes. One of the first steps is to draw up an inventory of the important features of the area. This could, depending on the goals of the reserve, include plant and animal inventories, water resources, and historical and archaeological sites. A baseline survey is partly a broad description, and partly it may be seen as the first cycle in the repeated measurements that comprise all monitoring systems. The baseline survey could incorporate initial measurements from rainfall stations, vegetation transects and game count surveys for example, but these would not constitute a complete monitoring programme.

At the same time reconnaissance mapping on a small or medium scale would be carried out for landforms, soils, water resources, vegetation communities and human settlement and land-use. A variety of complementary techniques is available for producing such maps, including the use of LANDSAT imagery, conventional aerial photography, low-level aerial survey and ground survey. All these techniques provide information at different mapping scales and are best used in combination (Thalen 1981). A major aim of map production is to provide a basis for subdivision or zoning of the area under study. Such zoning might be based on landforms and soils, bioclimatic variables, major habitats, "problem areas" or development areas. These subdivisions provide a framework for future sampling and help in the interpretation of data. The result would be a baseline survey report, giving a broad description of the area, a review of the literature and relevant historical events, inventory lists and a series of reconnaissance maps, all of the same scale and format. These maps might be produced as a series of transparent overlays so that broad ecological relationships can be demonstrated.

Detecting changes over time - the role of an ecosystem model in designing a monitoring programme

The problem with a baseline survey is that it cannot measure changes. A monitoring programme aims to measure the rates and directions of changes in ecosystems, ie their dynamics. The manager must adapt his understanding of ecosystems from that of a static, three dimensional system (it has distance, direction, depth) to include the fourth dimension (duration). The time dimension specifically includes hidden changes over a long-time

scale (eg in plant species composition, soil nutrient status) along with obvious short-term cycles and fluctuations (eg weather cycles, species generation length, animal movement). This understanding may be aided by constructing a crude, preliminary ecosystem model, or descriptive flow diagrams, drawing if necessary on the results from studies of similar ecosystems (eg Harris and Fowler 1975; Phillipson 1975). The object is to identify the major components, pathways, time scales and key variables in the ecosystem. Such a model would first describe the major components of the ecosystem and then the manner and degree to which these components are assumed to be connected. The model attempts to reflect the dynamics of the system. For instance, it might attempt to represent the interrelationships of rainfall, woodlands, grasslands, fire, elephants, other browsers, grazing herbivores, tsetse flies and people. The model should also help to identify the areas where future research should be concentrated. The model should be as simple as possible; it should be thought of as a scaffolding which will be modified or even dismantled once the full monitoring system has been implemented.

Detailed research on key variables and processes identified through the model should then be carried out. The aim of this research would be to test the initial assumptions contained in the model. The end result of such research, and consequent modification of the model, would be to identify what components need to be monitored and why. Ideally, these components would be ranked according to their importance in the ecosystem.

The development of a conceptual model of the way a reserve functions can play an important part in the process of evaluation and re-design of the monitoring system. Such models are useful in identifying research priorities. As data are synthesized and more is learnt about the dynamics of the ecosystem, so the initial simple model can be replaced by more sophisticated ones that focus on key processes, management options, and the monitoring system itself.

Logistical limitations to monitoring

When setting up a monitoring programme it is important to ensure that the field work is within the logistical capabilities of the parties concerned. The following questions should help to identify any limitations to the depth and detail of data collection:

- Are sufficient funds available both for capital expenditure on equipment and to cover running costs for an extended period?

- Is sufficient manpower available, are the people adequately trained, and is the monitoring straightforward enough for continuity to be assured even if staff replacements occur?

- Does accessibility and the availability of suitable vehicles limit the frequency and scope of field work?

The initial design of the monitoring system will depend as much on the answers to the above questions as on the results of the baseline studies and the initial model and research. Logistical limitations will inevitably reduce the scope of any "ideal system".

A statistician must be consulted at this stage to ensure that the initial monitoring design is statistically sound and that maximum information is obtainable from the limited data collected.

Initial monitoring

Having designed the monitoring system, the work programme can begin. Often the initial monitoring programme is virtually a research project in itself and many such programmes grow out of completed research projects. In some conservation organizations the initial research projects for an area are aimed at establishing guidelines for long-term monitoring. Ecosystem components that are expected to be static must be accurately measured at this stage, even if only to establish that they are static (eg mortality rates of woody species). Where monitoring is initiated in the absence of a research programme it is generally necessary to sample more frequently and at a higher intensity than might be anticipated necessary for the long term. The initial monitoring programme should run for several years and then be carefully evaluated.

First evaluation

Once the monitoring programme has been established the wildlife manager should carry out an initial evaluation by asking himself the following four questions:

- Do the data identify any gaps in understanding that should be the subject of more detailed research projects?

- Have any important components of the system been left out in the initial monitoring?

- Are the procedures adequate and is the accuracy and the precision of the data collected satisfactory?

- Which measurements can be left out in future?

If answers to these questions can be obtained then it provides an opportunity for the manager to make sure he is collecting only the data that are necessary to fulfill the aims of the monitoring programme. It should also enable him to identify early research priorities and to adjust his ecosystem model.

COMPONENTS OF A MONITORING SYSTEM

In trying to describe a generally applicable monitoring system it is necessary to cater for protected areas with widely differing data bases. They may vary from remote, undocumented areas such as the Dinder National Park in eastern Sudan to the extensively documented Kruger National Park in South Africa. The approach adopted here has been to list the components

that are essential or useful to monitor in reserves of radically different sizes, located in different bioclimatic zones, and that are subjected to different management approaches to achieve different goals. These provide a set of suggestions based on accumulated experience from the reserves that have been relatively well researched and monitored, eg Serengeti National Park, Kruger National Park and Hluhluwe-Umfolozi Game Reserve. For each component considered worth monitoring, the necessary frequency, scale of resolution, accuracy and precision is indicated for each type of reserve. However, it is emphasized that these are suggestions. It is the ecological characteristics of the individual reserves and their objectives that will ultimately determine the components to be monitored and the scale, frequency and precision of the monitoring.

Figure 5.2 shows some examples of African reserves in relation to their size and approximate annual rainfall. Most of the information on reserve size was obtained from Huntley (1978). These reserves were considered in the formulation of Table 5.1 located at the end of this chapter.

Frequency

As the different components of an ecosystem can change at different rates it is important to adjust the frequency of monitoring accordingly. This

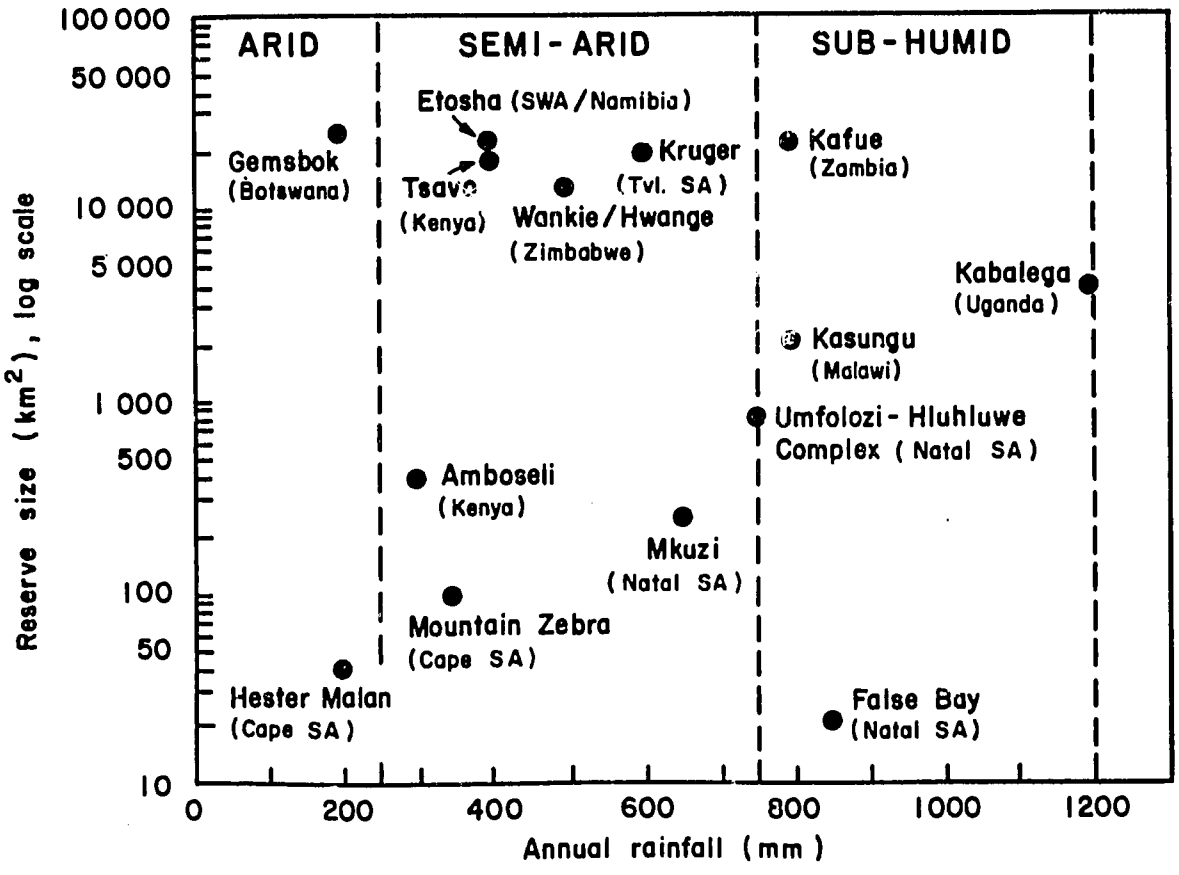

FIGURE 5.2. Examples of African reserves shown in relation to their size and approximate average annual rainfall

implies flexibility in monitoring; although one may monitor every year, it may not be necessary to monitor each facet of the system every time. For example, it may not be necessary to make total counts of an elephant population on an annual basis, but one may have to sample the calving rate every year.

A number of the important processes in arid and semi-arid ecosystems occur in a episodic manner, ie at irregular intervals. It is important that the frequency of monitoring should be sufficiently flexible to allow for the measurement of these episodic phenomena.

Scale

The scale of resolution is expressed as a grid size that indicates the sampling intensity required. The scale of monitoring depends on the scale at which the phenomenon of interest occurs. For example if the home range of an animal is 100 km^2, census data should not be recorded on a grid scale larger than 10 x 10 km.

Sampling - the accuracy and precision of estimates

Monitoring is repeated measurement in order to detect change through time. To do this, samples, averages and estimates of populations are used, because whole populations, almost invariably, cannot be accurately measured. The samples and averages used provide estimates of the true values. Of primary concern to the scientist designing a monitoring system is that his samples and averages give him either accurate estimates that are close to the true value, or precise estimates (indexes) that have a constant relationship to it.

Example: In a population of about 100 bushbuck an accurate estimate of 101 (average) would be obtained from sample counts giving estimates of 78, 95 and 130, ie an accurate estimate from imprecise counts. A totally different sampling method might produce count results of 73, 74 and 77 (average 75) which, if found to be consistently repeatable would result in a reliable index (simply multiply by 1,33) from precise but inaccurate estimates.

Good estimates depend on sampling being representative of the population as a whole. This is not an easy condition to satisfy, because in nature populations are not randomly or regularly distributed, they tend to be clumped. Samples can very easily produce biased and therefore misleading results. This bias can come from two sources - the person doing the sampling, or from a sampling system that is inappropriate for the peculiarities of the population. When designing a monitoring system the scientist must be familiar with the distribution of the whole population, and then use a sampling system to fit. If there are any doubts about the suitability of a sampling proposal it should be vetted by someone with specific biometric or statistical competence.

The higher the accuracy or precision of any estimate, the greater is the researchers confidence that the changes indicated are real and not a result

of bias or chance. There are several statistical tests that can be applied which will specify how much confidence may be had in such an estimate. These also require statistical competence.

A high degree of accuracy is only necessary when the true value of the component has to be known for assessing the performance of the ecological process. Often an index of this change is all that is required, the true value being almost irrelevant. However, when monitoring the rate of change in a potentially rapidly changing process, it is often important to have an accurate estimate (eg the first year survival rates of many large mammal species). A precise estimate is only required when it is necessary to detect small changes in the trend of a component. For example, in a long-lived large mammal species where the survival of a population depends on recruitment equalling or exceeding mortality, it would be necessary to have a precise estimate of any changes in the adult mortality rate.

Ecosystem components that require monitoring

These are listed separately for reserves in the arid, semi-arid and sub-humid bioclimatic zones. It is unnecessary to list components for reserves in the humid bioclimatic zone, as these ecosystems do not appear to be subject to problems associated with the abundance of large mammals.

How these lists should be used: They are for use by any manager and/or ecologist who plans to set up a monitoring programme in a protected area. It is necessary to monitor only the components that are required to achieve specific levels of understanding of the system's behaviour. The ecosystem components selected cover most of those that have general conservation significance. The completion of each cell of the table has been done with specific relevance to the three important bioclimatic zones containing Africa's large mammal reserves. Some components have been omitted from particular reserve size/ bioclimatic zone combinations because they are well monitored indirectly by another component.

It should be remembered when using these tables that monitoring is intended to detect change. Factors that are important, but manifestly static, need not be monitored. This implies that a good baseline survey has been carried out and that these factors will be considered during interpretation of the results of monitoring.

METHODS OF MEASURING COMPONENTS

Detailed treatments of monitoring methods have been given elsewhere (Grimsdell 1978; Macdonald and Brooks in prep). In this account, only a brief description will be given of some of the major components.

Rainfall

Rainfall is probably the most important variable in African ecosystems and must be included in all monitoring programmes. Except where daily rainfall records are needed (eg where intense rainstorms cause significant soil erosion) or may conveniently be obtained, weekly to monthly records are

normally adequate. The simplest method of recording monthly rainfall is by using storage gauges (metal pipes) containing a thin layer of oil to prevent evaporation. Various methods are available for analysing rainfall data (eg Norton-Griffiths et al 1975), but simple calculations of seasonal totals and their variation over time may be sufficient for many purposes. If sufficient rainfall data are available (more than 20 years) the probability of future droughts and floods may be calculated, which is of use in the evaluation of risk.

A comparison of precipitation rate with evaporation rate (per month or season) gives a useful index of availability of water to plants, a critical factor in arid and semi-arid areas (eg Western 1975).

Water table

The level and fluctuation characteristics of the water table may be critical factors in semi-arid environments, because marked changes can have significant effects on woody species, for example in Amboseli National Park (Western and van Praet 1973). Water table levels and fluctuations may be measured in boreholes with a plumbline (Boggie 1977), though the significance of such levels for plants will obviously depend on soil characteristics and the geological substrate.

Nutrient inflow and outflow

Changes in the nutrient status of catchments or ecosystems can be measured by comparing the rate of inflow (via rain and run off) and outflow (via run off and wind). Chemical analysis of rain and run off may be used for soluble nutrients and sediment weirs can be used to collect the major components of insoluble nutrient flow. Examples of such monitoring are rare in Africa, but can be found from North American forests (Bormann et al 1974). Monitoring of this kind is particularly relevant to baseline surveys in control areas, where one of the objectives is to measure long-term stability in terms of essential nutrients. Monitoring these components effectively is not easy, nor is it commonly practiced anywhere in the world.

Soil erosion

In natural landscapes there are various types of soil erosion, such as wind, sheet and gully erosion and mass soil movements. The moving agent is usually water but significant amounts of wind erosion take place in the poorly vegetated, semi-arid and arid zones. In most areas the "natural" rate of soil erosion is not known and would anyway be difficult to measure. However, what is of interest to a park manager is the extent of the enhanced or accelerated soil erosion which results from disturbances within the ecosystem or from extreme environmental influences.

Soil erosion is affected by four main variables, namely the ground cover and rooting characteristics of the vegetation, rainfall intensity, soil type and slope. These factors must be carefully considered when selecting sites for monitoring soil erosion. Physical loss of soil may be measured in many ways. Silt load and turbidity of run off provides indices for catchments, detailed levelling surveys with fixed points and pegs may be

used for localised sheet or wind erosion and the progress of gullies or mass soil movements may be measured from successive sets of aerial photographs. Detailed methods for measuring soil erosion are given by Dunne (1977) and Kirkby and Morgan (1980). At the risk of stating the obvious, managers are reminded of the particular need to measure the success or failure of soil reclamation measures, especially over the long term.

Habitat distribution

The size, distribution and relative positions of habitat or vegetation types and their ecotones are fundamental to determining the abundance and variety of plant and animal species in a reserve. Changes in habitat distribution may be monitored by aerial photographic methods, followed by ground checking. LANDSAT imagery can also be used for detecting broad changes in larger reserves and in particular in the catchments that surround protected areas. The establishment of fixed point photographs on the ground is a useful means of typifying habitat types in a baseline survey.

Woody canopy cover

Woody canopy cover can be measured accurately by large or medium scale aerial photography. For larger reserves where less accurate measures may be acceptable, visual estimation by low level aerial survey can be carried out (Western and Grimsdell 1979). Changes in woodland structure and species composition are probably best measured along fixed ground transects (Walker 1976). In situations where logistical considerations preclude accurate measurements, time-lapsed fixed point photography can provide an index of the trends both in structure and species composition.

Herbaceous cover

As with woodland structure, herbaceous cover can be recorded along fixed transects. For the broad changes in larger reserves, well documented visual estimation may be quite adequate. In very large reserves with limited staff this component may have to be assessed from a light aircraft. This is only of practical use in arid and semi-arid areas with sparse woody canopy cover and widely fluctuating herbaceous layer.

Levels of use of grass and browse

The extent of animal use of grass and browse species provides an index of the trend in the plant/herbivore relationship. These measurements must be related to local variables such as rainfall and fire in order to have relevance. An approach that has proved useful in the semi-arid to sub-humid Hluhluwe-Umfolozi reserve is the annual assessment of the extent of use of palatable grass and browse species at the end of the dry season. This is recorded by a formalized subjective assessment procedure (Macdonald and Brooks in prep).

Fire

Even in arid areas, where fires occur during periods after above average rainfall, the areas burnt each year should be recorded in every monitoring

programme. Where known, the reason the fire started should also be recorded. In large reserves burns can be conveniently mapped from a light aircraft. The season of burning is important to record as it affects the intensity of the fire, late dry season fires having different effects to early dry season fires. Fuel loads (measured for example by grass height and herbaceous cover) also affect the intensity of fires and are related to rainfall (eg Norton-Griffiths 1979).

Intentional burning is a common management practice in sub-humid and semi-arid areas. Recording the occurrence of these burns is generally easier than recording wildfires and just as essential. In the case of intentional burning there are additional data that should be recorded once the area has been selected.

- The specific purpose of each burn should be clearly defined and recorded (Chapter 4)

- Every time a burn is intended a pre-burn inspection of the area should be carried out to record the status of herb and shrub layers relative to the purpose of the burn.

- A detailed record of the type of burn achieved - head fire, back burn, wind and temperature conditions, patchiness, etc.

- Follow-up records on the recovery of the area and its use by herbivores, from one month to one or two years after the fire, relative to the purpose of the burn.

Distribution and abundance of large mammals

Much has been written on methods of counting animals and how animal distributions may be related to the environment (eg Norton-Griffiths 1978; Western and Grimsdell 1978; ILCA 1981). It should be pointed out that high accuracy is not always required and an index of abundance may be perfectly adequate (eg in control zones). Generally speaking for monitoring purposes an estimate is of greatest value if it is repeatable, ie having a precision that is not easily affected by chance or human error. This is particularly true of population estimates of abundant species. Only when counting rare species is accuracy likely to be more important. (See also page 84).

Size and structure of large mammal populations

Group Size. Average group size in large mammal populations may change over time in response to habitat change or disturbance. Such changes in a population's structure may affect its dynamics.

Examples: the apparent effect of human disturbance on group size of elephants in Uganda (Laws et al 1975), and the increase in the size of batchelor male groups of bontebok due to lack of predation and dispersal in the Bontebok National Park.

Sex and age structure of populations. Precise sex and age structure estimates for a population are among the most valuable data a manager can

obtain in order to understand the population dynamics of a species. The analysis should be considered as an adjunct to census data because without it interpretation can be ambiguous (Caughley 1977).

Mortality. Death rates of large herbivore populations may be important to monitor, particularly in arid and semi-arid areas subject to drought and in areas where illegal hunting is taking place. For very large herbivores, such as elephants, a reasonable index of mortality can be obtained by the ratio of live animals to dead (skeletons) observed in low level aerial surveys (Douglas-Hamilton and Hillman 1981). Ground surveys by transect or block counts of skeletons can also be employed, but because the survival of skeletons in the wild and the ability of people to find them are both subject to tremendous variability, these methods produce inconsistent results. It is important to relate the numbers of dead to live animals so that a rate or index of mortality can be obtained.

Animal condition, parasites and disease

Animal condition. Assessments of animal condition will reflect nutritional stress in response to unfavourable habitat conditions. It can be monitored by visual assessment (Riney 1960), examination of live animals, or post mortem inspection for kidney fat index, muscle weights etc (Hanks 1981).

Genetics of small populations. With small populations it is often important to know if one is dealing with genetically heterogeneous or homogeneous populations for the purpose of well planned translocation programmes. Monitoring of genetic indicators of homegeneity (eg blood proteins) has rarely been undertaken in African reserves, but could be an important consideration if these small populations are to be conserved. Tests on blood proteins have been used in the evaluation of animal systematics (Ferguson 1980).

Disease. It may be important to monitor the incidence of disease especially in sub-humid and humid areas; arid areas are relatively free of disease. The incidence of disease and parasites may be helpful in explaining mortality rates. The possibility of disease transmission to adjacent areas must also be taken into account. In the event of an epidemic or pandemic disease, it will be necessary to monitor at an increased frequency and resolution.

Indicator species

Research results might indicate that certain animal species (of any taxonomic group) are particularly sensitive to habitat changes. Monitoring of such species might provide a useful index of environmental change (Eisenberg 1980).

Insect herbivores

In certain regions insect herbivores (eg locusts, grasshoppers, army worm) may have a profound influence on herbaceous cover, which could then affect large herbivore populations. These events are likely to be episodic but should certainly be reported.

Human populations, distribution and land use

Human settlment, either inside or outside a reserve, can greatly affect large herbivore populations (eg through illegal hunting, competition for space or through indirect effects such as frequency of fire). Trends in human numbers and distribution can be obtained from national census data or from house counts obtained by low level aerial survey. Landuse changes can also indicate likely future pressures on reserves. These changes can be measured from aerial photographs or by low level aerial survey (ILCA 1981).

Visitor impact

Visitors can have a significant impact on habitats and on animals (eg large predators) in certain reserves, for example Amboseli National Park, Kenya (Western and Henry 1979). In such reserves it may be important to monitor tourist numbers and distributions. Well used parks need to limit tourist access to prevent overcrowding, not only from an ecological point of view but from an aesthetic or enjoyment viewpoint as well.

ORGANIZATION OF INFORMATION FROM A MONITORING SYSTEM

Monitoring is not an end in itself, it provides information that is to be used. It is not merely the collection of data. Thus in planning the types of data to be collected one must be clear about their ultimate use in both the short and long term. All monitoring procedures must be adequately documented so that, in the absence of staff continuity, the system will continue to function effectively. Simple, standardized data collection sheets should be designed so that comparable data can be collected by different people.

If the suggestions made below are followed, then the continuity of data flow and constant interpretation will also follow. It must be emphasized that this outline describes a chain consisting of; data collection, storage, corrections, retrieval, analysis and presentation. If any link in this chain is weak then the whole monitoring system could fall apart.

Storage and checking

Ideally a computer-based system of data storage and retrieval should be used. Without this aid it is difficult to use monitoring data effectively and to be flexible in one's monitoring approach. It would be preferable to have a micro-computer available at each park or game reserve rather than to send the data to a large central computer some distance away. Computer programmes suitable for each reserve's particular needs can be drawn up by an appropriate agency or consultant.

Field data should be transferred from collection sheets or data tapes to the computer with the minimum of delay. Once transferred, the data in the computer should be retrieved immediately in a form that makes it easy for the people who collected them to check for errors of collection and/or

transfer. New technologies for the direct recording of data, in a form suitable for computer processing, should be employed wherever possible.

Common computer storage devices include disks, magnetic tapes and floppy disks. Whatever storage device is being used, originals or duplicates of all data, descriptions and photographs should be kept separately in a secure place, protected specifically from theft, fire, chemicals, damp, insects and termites. In time they will be valued as rare antiques and priceless historical records.

Information flow

Once the computer data have been checked and corrected there must be a clear schedule of who must see the data, when, and in what form they must be presented. Certain people may need to see the data presented in different ways. It should be remembered that the cost of presenting the data is negligible if compared with the cost of collection, and if presentation is not effective, the whole effort is a waste of time.

Example: Data from an aerial census might be presented as maps showing the location of individuals or groups or simply blocks of high or low density.

This may be adequate for short-term management purposes, but more detailed tables and/or graphs may be needed for scientific papers and annual reports.

Care must also be taken to qualify the data so that the way in which they are presented reflects their accuracy. Comments on weather conditions, experience of the recorder, the "impressions" of the recorder all help to detect possible bias in the data, which will affect the managers confidence in the results.

Example: A wildebeest count in year A is 5 300 animals; in year B it is 5 000. When put into a table, there is a danger that management will conclude that this wildebeest population is declining. They are likely to interpret the data more correctly if the data are presented in a graph with confidence limits shown and a description of the conditions under which the two counts were carried out.

Analysis and interpretation

Biologists need to be particularly cautious when interpreting statistical results. For instance, it may be easy to conclude that two highly correlated variables imply a strong cause and effect relationship. This might in fact be quite misleading. The confirmation of the assumed causal relationship may have to be established by a research project that takes into account many more variables. It should be appreciated that certain information does not require sophisticated statistical analysis. However where it does, statistical competence must be obtained (and preferably verified) for both the design and analysis phases of any monitoring programme. The statistical tenderfoot needs to be aware that the science of statistics is able to manipulate data dangerously.

The purpose of collecting the data will indictate how they should be analysed. Having a micro-computer with a graphic display unit enables one to "play" with the data by displaying them in different combinations and ways. This may lead to unexpected results which must then be checked out by alternative statistical methods. The biologist/statistician is the best person to examine the data, and the computer system must enable him to do so with the minimum knowledge of computers. Statisticians should be used to confirm or repudiate the suspicions of the biologist.

Example: Animal density maps from an aerial census might suggest that sable antelope are avoiding areas occupied by impala. Once the maps have stimulated this suggestion a statistician can perform the required tests of significance.

If these suggestions are followed, then continuity of data flow and regularity of interpretation of trends, will logically follow. It must be emphasised that this outline describes a chain of activities relating to the data generated by monitoring. The links in the chain are: planning, collection, storage, correction, retrieval, analysis, presentation and re-evaluation. If any link in the chain is weak ....

THE NEED FOR REGULAR RE-EVALUATION

It must be stressed that a monitoring system is not something that can be designed once and then continued unchanged forever. Systems designed in that way are eventually reduced to a ritual of often feverish but useless data collection. It is essential, therefore, to build into the monitoring system a deliberate control mechanism that forces regular re-evaluation, and the questions asked at the first evaluation must be reiterated over and over again. The answers to these questions will lead, as in Figure 5.1, to up-dated designs and to new research projects. It is desirable that re-evaluation be carried out by an outside individual or organization. In this way an objective appraisal of the monitoring system, and its relevance to the stated goals of the reserve is more likely.

Finally, it is almost routine that monitoring budgets are severely limited, which means some, perhaps important, data are not collected or are ignored. In areas of active field management, the decision to continue monitoring can be based on whether or not the data are actually being <u>used</u>. If not, then collection could either be terminated or, if it has potential value in the future, it could be simplified in scale or frequency to reduce expenses. In this way allowance is made, at least in part, for unforseen future needs. Clear, repeatable records all serve as valuable bench marks in time.

KEY TO TABLE 5.1

Type of Goal	Essential for any understanding of the system	Essential for detailed understanding of the system	Useful to monitor	Unnecessary to monitor
Minimal management area	A	A	a	
Management for ecological objectives	B	B	b	
Management for economic objectives	C	C	c	—

MINIMUM RECORDING FREQUENCY

Daily = 1
Monthly = 2
Seasonal = 3
Yearly = 4
> Yearly = 5

1 X
Abc
IV ++

Sample grid cell from Table 5.1

X - highly accurate
Y - moderate
Z - low (often a visual estimate)

RECOMMENDED SCALE
(grid square size)

less than 1 x 1 km = I
1 x 1 - 2 x 2 km = II
2 x 2 - 5 x 5 km = III
5 x 5 - 10 x 10 km = IV
10 x 10 - 20 x 20 km = V

PRECISION REQUIRED

+++ - highly precise
++ - moderate
+ - low

TABLE 5.1. Monitoring for processes linked to large mammal abundance in reserves

COMPONENTS	ARID ZONE RESERVE SIZE (km^2)				SEMI ARID ZONE RESERVE SIZE (km^2)				SUB-HUMID ZONE RESERVE SIZE (km^2)			
CLIMATE	10	100	1000	10000	10	100	1000	10000	10	100	1000	10000
Rainfall		2 X ABC III+++	2 X ABC IV +++	2 Y ABC V ++	1 X ABC III+++	1 X ABC III+++	1 X ABC IV +++	2 X ABC IV +++	1 X ABC III+++	1 X ABC III+++	1 X ABC III+++	1 X ABC IV +++
Evaporation							2 Z ab III ++	2 Z ab IV ++	1 X abC III+++	1 X abC IV +++	1 X abC IV +++	3 X abc IV +++
Temperature					1 Z ab III ++	1 Z ab IV ++	1 Z ab IV +	2 Z ab IV +	1 X ABC III+++	1 X ABC IV +++	1 X ABC IV +++	1 X ABC IV +++
WATER												
Available water distribution		2 X ABC III +	2 X ABC III +	3 Y ABC IV +	2 X ABC I ++	3 Y ABC II ++	3 Y ABC III +	4 Y ABC IV +				
Water table			4 Z ABC IV ++	4 Z ABC IV ++	4 Z ABC II ++	4 Z ABC III ++	4 Z ABC III ++	4 Z ABC IV ++	3 Y ABC III+++	3 Y ABC IV +++	3 Y ABC IV +++	3 Y abc IV +++
Stream/river flow			2 Z A IV +	2 Z A IV +		3 Y A ++	3 Y AB ++	3 Y AB ++	1 X ABC +++	1 X ABC +++	1 X ABC +++	1 X ABC +++
NUTRIENTS												
Nutrient inflow									4 X A III+++	4 X A IV +++	4 X A IV +++	4 X A IV +++
Nutrient outflow									4 X Ab +++	4 X Ab +++	4 X Ab +++	4 X Ab ++
SOIL												
Wind erosion		4 Z ABC III +	4 Z Ab III +	4 Z Ab IV +		4 Z Abc IV ++	4 Z Abc IV ++	4 Z abc IV ++				
Water erosion		4 Z AB III +	5 Z AB III +	5 Z AB III +	4 Z ABC II ++	4 Z ABC III ++	4 Z ABC III ++	5 Z ABC III ++	4 Y ABC I +++	4 Y ABC I ++	4 Y ABC II ++	5 Z ABC III ++
Sediment load (from catchments)								3 Y ab +	1 X Ab +++	2 X Ab +++	4 X Ab +++	4 X Ab +++
VEGETATION												
Habitat distribution		5 Y ABC I ++	5 Y ABc I ++	5 Y ABc III ++	5 Y ABC I +++	5 Y ABC I ++	5 Y ABC II ++	5 Y ABC III ++	5 Y ABC	5 Y ABC	5 Y ABC	5 Y ABC
Woody canopy cover					5 X ABC I +++	5 X ABC I ++	5 Y ABC II ++	5 Y ABC III ++	4 Y ABC I +++	4 Y ABC II ++	5 Y ABC III ++	5 Z ABC IV ++
Herbaceous cover		3 Z ABC III +	3 Z ABC III +	3 Z ABC IV +	4 Z ABC I +++	4 Z ABC I +++	4 Z ABC II ++	4 Z ABC III ++	5 Y ABC I ++	5 Y abC II +	5 Y abc IV +	
Species composition		4 Z AB III +	4 Z AB IV ++	4 Z AB IV +	4 Y ABC I ++	5 Y ABC I ++	5 Y ABC II +	5 Z ABC III +	5 Y abC I +	5 Y c II +		
Production and quality		3 Y ac III ++	3 Y ac III ++	3 Y ac IV ++	4 Y C I ++	4 Y C I ++			4 Y c I ++			
Use by herbivores					4 X ABC I ++	4 Y ABC II ++	4 Z ABc III ++	5 Z abc IV ++	4 Z ABC I ++	4 Z abc II ++	4 Z abc IV ++	
FIRE												
Area burnt		4 X ABC III ++	4 X ABC IV +	4 X ABC IV +	4 X ABC I ++	4 X ABC II ++	4 Y ABC II ++	4 Y ABC II ++	4 Y ABC I ++	4 Y ABC II ++	4 Y ABC II ++	4 Y ABC IV ++

COMPONENTS	ARID ZONE: RESERVE SIZE (km^2)				SEMI ARID ZONE: RESERVE SIZE (km^2)				SUB-HUMID ZONE: RESERVE SIZE (km^2)			
	10	100	1000	10000	10	100	1000	10000	10	100	1000	10000
FIRE (cont)												
Season of burn					1 X ABC I	1 X ABC II	2 Y ABC II	3 Z ABC IV	1 X ABC I	1 X ABC II	2 Y ABC II	3 Z ABC IV
Type of fire					1 AB	1 Ab	2 ab	2 ab	1 AB	1 Ab	2 Ab	
LARGE HERBIVORES												
Number or index		3 X ABC III+++	4 Y aBC IV +++	4 Y aBC IV +++	5 Y ABC III+++	5 Y ABC III+++	5 Y ABC III+++	5 Y ABC III+++	5 Y ABC III+++	5 Y ABC III+++	5 Y ABC III+++	5 Y ABC III+++
Distribution		3 Y ABC III +	3 Y ABC III +	3 Y ABC IV +	5 Y ABC II ++	5 Y ABC II ++	5 Y ABC III ++	5 Y ABC III ++	5 Y ABC II ++	5 Y ABC II ++	5 Y ABC III ++	5 Y ABC III ++
Group size		3 Z ab IV +	4 Z ab IV +	4 Z ab IV +	5 Y abc III ++	5 Y abc IV ++	5 Y abc IV ++	5 Y abc IV ++	3 Y abc III ++	3 Y abc IV ++	3 Y abc IV ++	5 Y abc IV ++
Population structure		4 X abC III+++	4 X C IV +++	4 X C IV +++	4 X aBC III+++	4 X aBC IV +++	4 X aBC IV +++	4 X aBC IV +++	4 X aBC III+++	4 X aBC IV +++	4 X aBC IV +++	4 X aBC IV +++
Condition		3 Z ABC IV +	4 Z abC IV ++	4 Z abC IV ++	4 Y abC III ++	4 Y abC IV ++	4 Y abC IV ++	4 Y abC IV ++	4 Y abc III ++	4 Y abc IV ++	4 Y abc IV ++	4 Y abc IV ++
Mortality rate		3 Y ABC III ++	3 Y ABC IV ++	3 Y ABC V ++	4 Y ABC III ++	4 Y ABC IV ++	4 Y ABC IV ++	4 Y ABC IV ++	4 Y ABC III ++	4 Y ABC IV ++	4 Y ABC IV ++	4 Y ABC IV ++
LARGE PREDATORS (Numbers and distribution)		remove preda-tors			remove large predators		4 Y ABC IV ++	4 Z abc IV ++	remove predators		4 Y abc IV ++	4 Z abc IV ++
GENETICS OF SMALL POPULATIONS		5 X ABC IV ++	5 Y abc IV ++	5 Y abc IV ++	5 X ABC +++	5 X ABC +++	5 X abc +++	5 X abc +++	5 X ABC +++	5 X ABC +++		
DISEASE					2 Y ABC II ++	2 Y ABC III ++	3 Y ABC IV ++	3 Y ABC IV ++	2 Y ABC II ++	3 Y ABC III ++	3 Y ABC IV ++	3 Y ABC IV ++
INSECT HERBIVORES		3 Z ABC III +	3 Z ABC IV +	3 Z ABC IV +	3 Z ABC	3 Z abc	3 Z abc	4 Z ab	3 Z ABC II ++	3 Z abc III ++	3 Z abc IV ++	
INDICATOR SPECIES		3 Z ab IV +	3 Z ab IV +	3 Z ab IV +	3 Z AB II ++	3 Z AB III +	3 Z AB IV +	4 Z AB IV +	3 Z ab II ++	3 Z ab III ++	4 Z ab IV ++	4 Z ab IV ++
HUMAN PRESENCE												
Numbers					1 X ABC I ++	1 X ABC II ++	2 X ABC III ++	3 X ABC IV ++	1 X ABC I ++	1 X ABC II ++	2 Z ABC III ++	3 Z ABC IV ++
Distribution		1 X ABC II +	3 Z ABC IV +	3 Z ABC IV +	1 ABC I ++	1 ABC II ++	2 ABC III ++	3 ABC IV ++	1 X ABC I ++	1 X ABC II ++	2 Z ABC III ++	3 Z ABC IV ++
Land use (if applicable)					3 Y ABC I ++	3 Y ABC III ++	3 Y ABC III ++	3 Y ABC IV ++	3 Y ABC I ++	3 Y ABC III ++	3 Y ABC III ++	3 Y ABC IV ++
Visitor impact		1 X ABC II +	2 X ABC IV +++	2 X ABC IV +++	2 X ABC I +++	2 X ABC II +++	2 X ABC III+++	3 X ABC IV +++	1 Z ABC I +	4 Z ABC II +	4 Z ABC II +	
EXTERNAL												
Human numbers and distribution		4 Z ab IV ++	4 Z ab IV +	4 ab IV +	5 Y ABC II ++	5 Y ABC III ++	5 Y ABC III ++	5 Y ABC IV ++	5 Y ABC I +++	5 Y ABC II +++	5 Y ABC III+++	5 Y ABC IV +++
Catchment changes					5 X ABC ++	5 Y AB ++	5 Y AB ++	5 Z AB ++	5 X AB ++	5 Y AB ++	5 Y AB ++	5 Z AB ++

REFERENCES

(Much of the information included in these guidelines has come directly from the combined experience of the participants. This, together with a desire to present a reasonably uncluttered text, has resulted in a patchy and inadequate list of references. Chapter 5 which has the greatest need for reference material, is the only exception to this acknowledged shortcoming).

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