Plenary Paper Three
Elephants and Habitats: the Need for Clear Objectives

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Abstract

In all places where elephants have been managed, the relevant authorities have expressed concern over elephant impact on vegetation and the risk of irreversible habitat change. However, in many cases, management objectives have not been clearly defined, or where objectives are clear, their basis may be not entirely logical.

Management plans for protected areas often include the preservation of “biological diversity” and occasionally even ecological processes as high level objectives. However, in many cases in southern Africa for example, the ecological prcess of elephant/habitat interaction has been regarded as a special case. Extensive woodlands have been chosen as the desirable habitat condition, and the management target or “carrying capacity” for elephants has been set - and maintained by culling - at such a low density that their use of these habitats will have little effect on trees or on other species, either positively or negatively. An alternative view slowly gaining acceptance is that episodic change is an essential feature of African ecosystems and that attempting to maintain a single fixed state - even one of high biodiversity - over the entire range of a population could result in loss of species and habitat instability. Under this view, the use of the term “carrying capacity” is not appropriate, since it prescribes constant conditions selected by the value judgements of the managers. The latter are often not acknowledged or are poorly defined.

Appropriate management can be guided by information from research, but in turn habitat research must be guided by clear management objectives. There should be at least conceptual, if not numerical, models of the elephant/habitat interaction, the regulation of elephant and tree populations, and the influence of other environmental factors. Management actions should avoid being “reactive” and instead provide data to test or refine the conceptual models. The ecological processes which move the system from one state to another and the requirements of plant and animal species which are affected by the elephant-tree interaction should be key areas of study.

Introduction

Managers of areas which contain elephants are faced with an apparent dilemma: they wish to keep elephants in the system, but are often concerned that the considerable impact elephants may exert on habitat structure may have undesirable, possibly irreversible, consequences for the plant and animal communities in their range. Because both elephants and trees are long-lived, the interaction may take decades to unfold. The causes of present-day conditions may lie many years in the past and the outcome some time in the future.

Such long term dynamics make it difficult for researchers to get answers of immediate use to managers, and although much research has been undertaken, there are very few examples where the ecological processes at work are well understood. However, in all cases management authorities must formulate action plans in the present, even when good data are lacking. This “management with uncertainty” has left considerable room for argument, particularly when political, ethical and emotive values enter the equation.

In much of eastern Africa, the central issues of elephant management have changed through time. In the 1 960s, there were many reports of elephant “overpopulation” in different parks and concern over habitat change - reviewed for example by Laws (1970) - with considerable debate over the appropriate management action. Then in the 1970s and 1980s, the accelerated, uncontrolled ivory trade changed "the elephant problem" to one of decline and local extinction through overhunting. Decisions on how to manage elephant habitats have been postponed, but authorities in east Africa have recognised that the issue, while remote at the moment, must be faced in the future (Poole *et al* 1992).

Meanwhile, most of southern Africa remained relatively free of intensive poaching, and the question of elephant-habitat interaction has been faced for a longer period of time. Managers in several southern African countries have formulated policies on elephant and habitat management, derived in part, it seems, from an agricultural background of strict control over nature. Generally, the problem is that elephants threaten to alter the woodlands which were found in the area in the early part of the century (Pienaar 1969, Martin & Conybeare 1992). These woodlands have been viewed as the pristine condition of habitat and the solution is to cull elephants to keep their densities and habitat impact low. How≠ever, some workers (e.g. Viljoen 1988) have recently suggested that tree densities in parks like Kruger may have "increased abnormally" when elephants were eliminated by hunters in the early 1900s, and that tree loss may have been a "natural process of elimination" when they began to recolonize the area.

This paper is intended to promote discussion on the subject of elephant - habitat interactions. I start with a review of management plans from different countries, mainly in southern Africa. I follow with discussions of process-oriented management in wildlife conservation, the use and misuse of the term "carrying capacity", and some models which have been used to approximate elephant, tree and interaction dynamics.

Management Objectives

Management objectives of any given area should depend on its form of land use. In national parks (NPs), game reserves (GRs) and other protected areas, the objectives are primarily nature conservation. In this section I will review some management plans for protected areas in southern Africa. My sources were the documents available to me at the time of writing and in many cases they were draft plans in typescript form which may have already been superseded by improved versions. I would ask that no one be offended if I have included items which are now out of date. Some examples will also be given for other areas where the primary objective is commercial tourism or animal production.

Within parks in southern Africa, the general emphasis appears to be the conservation of animal and plant species, recently termed "biological diversity". This has been noted as the primary objective or policy in Etosha NP, Namibia (Anon 1985), Hwange NP, Zimbabwe (Anon 1990), Kruger NP (Joubert 1986) and Natal Parks (Grobler 1983) in South Africa and as a secondary objective in the Botswana elephant range (Anon 1991). Some of the local authorities also include the conservation of ecological processes (Hwange), "essential life support systems" (Botswana) or "dynamic interactions" (Kruger) as a secondary objective. In the latter it was noted that the park ecosystems are affected by outside influences and that, within a policy of minimum interference, management should seek to "simulate natural conditions".

In Etosha, "optimal stocking rate/ratios" for eephants and other species are invoked but "optimal" is not defined. In Kruger, the elephant and buffalo populations are to be kept "well below the peaks... of the potential carrying capacity", although this term is also not defined. The condition of woodlands when the Park was created in 1926 is the target, with the earliest aerial photos being available from the 1940s. In Zimbabwe, it has been estimated, though not yet established empirically, that elephant densities greater than 1/km^2 will have unsustainable and undesirable impacts on mature canopy woodlands. The woodland cover visible in aerial photos of 1959 was the chosen baseline.

The determination of limits of acceptable (=permissable) change in the state of habitats (Bell 1983) was noted as an important goal in Hwange and Etosha NPs and a comprehensive exercise of zoning the parks for management treatments has been undertaken. In Hwange, fairly narrow numerical limits to such factors as bare soil and tree canopy cover have been set, while in Etosha these limits are still under review.

Thus, while conservation of ecological processes is given some importance in these areas, the authorities primarily wish to maintain a catalogue of existing species and habitats. The ideal condition for woodland habitats is that which was found in the early to mid parts of the century, regarded as the pristine natural state, or at an least aesthetically pleasing one (Martin & Conybeare 1992). Since these trees flourished when elephants had been reduced or removed by hunters, an upper limit has been set on elephant abundance in order to achieve the goal of preserving the woodlands and associated species. The impact of elephants on habitats is now seen as a threat to their own survival as well as other species of concern (Hall-Martin 1990, Martin & Conybeare 1992), although no data have been presented to confirm that this would happen.

clearly stated (Ferrar 1990). Ecological processes do not appear to be an issue here and limits are set on all wildlife species.

On cattle ranches which are open to elephant use, it would appear that moderate elephant densities are beneficial to ranchers. As noted by van Wijngaarden (1985), ranchers adjacent to Tsavo East National Park in Kenya found that elephants helped to keep rangelands clear of bush, which improved the grazing opportunities for livestock. When elephant densities were reduced through poaching, bush cover began to

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increase, to the detriment of livestock.

In Botswana, the elephant population had grown large and woodland change had already taken place by the time a management policy was written. The 1990 elephant population size was set as an arbitrary interim target with the intention of preventing further change in the remaining woodlands while research and policy review takes place. However, since elephant numbers were already high, simply holding them constant is unlikely to succeed in preventing change.

In Pilansberg GR, which is a wildlife viewing area reconstructed from farmland, the primary goal of maintaining a representative range of wildlife species for the enjoyment of tourists and other visitors was

“Carrying Capacity”

Many managers of elephant populations continue to use the term “carrying capacity” as if it has an objective meaning grounded in ecological reality. The view that there is a self-defined carrying capacity for an area which is “ecologically correct”, the one animal density which will popular account of wildlife management principles, yet it blandly assumes a single value system when in fact there are a great variety, each of which sets its own limits of acceptability for the density of plants and animals.

More than a decade ago Caughley (1979) pointed out that the definition of “carrying capacity””depends on the goals of the manager. He noted that many wildlife managers tend to borrow the approach of range management as applied to commercial livestock production, that of maximum economic return from cattle herds at moderate densities. The population level returning maximum sustainable yield was described by Caughley as “economic carrying capacity”. However, animals left to their own devices are likely to reach “ecological carrying capacity”, which is set by the habitat’s ability to sustain life. This would be a higher population level, and because of greater use by the herbivores, the plant community would appear to be “overutilised” to the cattle fanner, but not necessarily to the manager of a protected area.

Caughley’s point was reviewed and extended by Bell (1985b, p.153), who concluded that’“the only embracing definition of carrying capacity is: ‘That density of animals and plants that allows the manager to get what he wants out of the system’.” Bell noted there are no “natural” points on the isocline of plant-herbivore equilibrium, independent of human values. The manager’s target species or communities, the densities of the other species which will interact with these targets and other factors which could affect from the interaction must all be included in his personal definition of “carrying capacity”.

Behnke & Scoones (1992) illustrated the point clearly with examples of a few definitions from the range of possibilities. A reserve manager wishing to provide a high density of certain animals for tourists to see would set a “camera carrying capacity” at a higher level than “economic carrying capacity” and lower than or equal to ”ecological carrying capacity”. A gamne rancher intent on meat or hide production would set a target more in the area of “economic carrying capacity”. with fewer animals amid more, or different, vegetation from that in a game viewing area. And a manager keen to preserve certain animal or plant species which are sensitive to the habitat change induced by a given herbivore would set an even lower “species preservation“carrying capacity” for that forager.

When there are so many different ways of defining a term, its meaning becomes lost. With such potential for abuse, it would appear best to give “carrying capacity” a rest and focus instead on management objectives and the densities of animals and plants they dictate. A second and perhaps more important problem with the concept of a single target “carrying capacity” is that it describes an ideal equilibrium state for a system which is unlikely to be at or even close to equilibrium for much of the time. As I note in the following section, most African ecosystems are characterised by great variability in climate and other factors, which affects the interactions between herbivores and their habitats. For a manager, any single set of conditions, unless it has broad limits of acceptable change, is likely to be an elusive goal.

Ecological Processes

Walker (1989) reviewed the literature on ecosystem diversity and stability in relation to conservation. He noted that there has been confusion over interpretation of the theory, with the term “constancy” equated with “good”. He pointed out that in fact the conservation goal of achieving persistence of a high richness of species depends on complex systems remaining ***nonconstant*** and ***unstable,*** with fluctuations and disturbance allowing the coexistence of many species through time and a space. Management has often been aimed at stabilising the system - dampening fluctuations in numbers, spreading animals evenly over the landscape (Hall-Martin 1990) - in the short term, but these activities are likely to reduce species diversity over the longer term. In the case of elephant - tree systems, Martin & Conybeare (1992) cautioned that there is a risk in allowing elephants to carry the system across what may (or may not) be a boundary from woodlands to more open habitats, and that this risk is unacceptable. Walker (1989) would argue that there is equally a risk of loss of species if the dense woodland equilibrium condition is maintained indefinititely over the whole wildlife estate.

Episodic events such as fire, frost, drought, changes in hydrology, and animal population eruptions and crashes are known to be common features of savanna ecosystems (Walker 1989; Berry & Siegfried 1991). Since many of these factors, particularly the abiotic ones, are beyond the control of managers, and since they may exert major influences on ecosystem structure, they should be a focus of management thinking, rather than the more common concern over maintaining stable numbers of a relatively few animal species.

Westoby *et al* (1989), echoed by Behnke & Scoones (1992), proposed a shift in approach to management of rangelands, including wildlife areas, from attempting to maintain systems in or close to a single, fixed equilibrium state. Instead they advocated process-oriented management; the identification of key processes which could shift the system from one state to another, for example woodland to grassland. It would need to be determined if the shifts between states are continuous or if there is an abrupt change across a boundary to an alternative "stable state", where a new factor takes over control of the state of the system. If the system has such boundaries and "multiple stable states", the manager must know when and how to take advantage of conditions which would allow a shift back towards the preferred state. Westoby"*et al* (1989) termed this approach "opportunistic management", and emphasized the importance of working with ecological processes, rather than forcing the system to sit at an arbitrary equilibrium.

Models of Population Dynamics and Habitat Interaction

Part of the problem managers face in managing "natural" ecological dynamics is in the definition of""natural"; managers need a formal description of the hypothesized""natural" mechanisms for comparison against observations. Logical description and exploration of interactive systems is best done through models; when data from the real world are available, parameter estimates can then be inserted to see how they affect the projected outcome. This section contains a brief, and consequently inadequate, review of some of the modelling approaches to elephant - habitat interactions.

Some models have dealt with elephant population dynamics on their own. Spinage (1990) attempted to fit a logistic curve to a limited dataset from Botswana; his only reference to habitat was the suggestion that by reaching K on the curve, the elephants would have reduced the Chobe woodlands to bare sand, leaving the definition of K (which should be "ecological carrying capacity") in a theoretical muddle. Croze"*et al* (1981) included more demographic detail and avoided the pitfalls of the logistic equation in their transition matrix model, but "habitat" was represented only by a cyclic mathematical function.

Some models have been developed to explore the consequences of different elephant management regimes. Barnes (1983) looked at the possible trajectory of different tree population dynamics with given fixed elephant densities in Ruaha NP, Tanzania. Craig (1992) predicted equilibrium woodland canopy cover at different elephant densities for Zimbabwe parks. Norton-Griffiths (1979) and Pellew (1983) looked at the influence of fire and other browsers on tree dynamics in the southern Serengeti. The concepts of single v multiple stable states were examined by Dublin *et a!* (1990) in models which simulated tree population dynamics at fixed elephant densities and fire regimes in the northern Serengeti/Mara.

Relatively few attempts have been made to examine the dynamics of freely interacting elephant and tree populations. Caughley (1976) used simple logistic models to show how stable limit cycles could occur under certain specific circumstances. Van Wijngaarden (1985) employed a basic systems model to explore the possible dynamics of elephants, trees and other herbivore species. At the broader conceptual level, Bell (1985a) proposed a framework for understanding how soil nutrients and infiltration capacity may interact with the abundance of large herbivores such as elephants to produce stable or unstable system dynamics.

Many authorities assume that dispersal, rather than *in situ* food limitation, is the important mechanism in elephant population regulation and that a significant disturbance which humans have introduced is the blocking of dispersal routes. This influence on population dynamics was explored theoretically by Owen-Smith (1983) amid Craig (in press) but more work and data are needed before conclusions can be drawn.

While these initial efforts have provided some insight into possible outcomes of the elephant habitat interaction, there is a clear need for the development of more comprehensive models which incorporate the dynamics of both elephant and tree populations and the interaction between them. An element of spatial heterogeneity should also be included. Progress in this field need not involve the building of ever more complex systems models. The approach of "rule-based" modeling (Starfield & Bleloch 1986), which avoids strict adherence to specific mathematical equations such as the logistic, makes use of little, large or increasing datasets, and incorporates both predictable and episodic events, is most promising.

Conclusions

Most wildlife managers agree that conservation of a high diversity of plant and animal species should be the goal of their protected areas, and some have stated that eoological processes should also be preserved. However, in many cases, there is a view that particular woodland habitats must be maintained in much the same state as they were found at a specific point in time. The fear is that if elephant - habitat interactions are allowed to proceed unchecked there will be unacceptable change in habitats and loss of species diversity. Since there are few definitive data or models to go on, the fear of risking irreversible change may be justified. On the other hand, there may be an equal risk in attempting to hold ecosystems at fixed equilibrium in the face of ecological processes. This contradiction in risk assessment is reflected in some of the contradictions in the stated goals of park authorities in southern Africa.

The approach of "adaptive management", where actions are designed to provide information on the state and function of the ecosystem under management, has been advocated (Bell 1983, 1985; Martin & Conybeare 1992) but rarely practiced by essentially conservative wildlife managers. A more confident approach to management and research along the lines proposed by Westoby *et al* (1989) and Walker (1989), coupled with improved models and a genuine interest in finding out how systems work, would appear to be the way forward. This could best be achieved by avoiding such concepts as fixed equilibria, embodied by the obsolete term "carrying capacity", and giving greater scope to ecological processes within at least some part of elephant ranges.

Variety in management strategies would generate spatial and temporal heterogeneity, allowing greater species diversity and providing the possibility of experimental treatment blocks. Research on other components of elephant - habitat systems, such as the habitat requirements and vulnerabilities of other animal and plant species and on the influence of fire and other episodic disturbance factors should be undertaken.

Whatever the approach adopted, management should have clear goals and objectives which do not conflict. Measureable objectives, such as limits of acceptable change - broad or narrow -should be identified so that research can have a target, and management can be informed on the progress or otherwise towards its goals.

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Footnote: The terms of reference and discussion summary for the elephant-habitat working group will be published in the next issue of Pachyderm.