CHAPTER 4
CHANGES IN ECOLOGY AND CONSERVATION: SCIENTIFIC CONTEXT FOR THE REVIEW PROCESS

The past: Managing elephants to protect the 'balance of nature'

The rampant exploitation of wildlife in the early colonial era, and changing philosophies of ecology and conservation management over the last century, have left their mark on South Africa's national parks and elephant populations. The following account offers both a historical and conceptual context for the ecological aspects of the elephant management debate.

The African Elephant (*Loxodonta africana*) once occurred or potentially occurred over most of South Africa (Figure 4), but what regional densities these populations may have attained can now only be guessed at. Ivory hunting and the expansion of human settlements and agricultural areas swiftly reduced elephant numbers and distribution. By 1900, elephants in South Africa were confined to remnant populations in the vicinity of Knysna, Addo, the Tembe area of Maputaland and possibly the Olifants Gorge in what is today the Kruger National Park (KNP)[4]. At the same time, populations of many other game species had been devastated by hunting and the rinderpest epidemic of the 1890s. Parks such as Kruger were proclaimed to try to protect what little game remained, and over time to replenish the area's once abundant wildlife resources.

Figure 4: Historical distribution of elephants in the area covered by the present South Africa, based on skeletal material, indigenous art and historical records (adapted from Ebedes et al., 1995[44]). However, it is not known how much of this distribution represented resident elephants versus transient elephants (occasional visitors).

Prior to the 1930s, management was focused on the preservation of parks as natural areas and on restocking their game populations. The National Protected Areas Act of 1926 introduced a new consideration – tourists. A new set of stakeholders and interests was created, along with considerable potential for future income generation for parks. In the early years, management of animal populations was entirely *laissez faire* – the only management intervention being the protection provided from hunting. In KNP in the 1930s a slow shift began toward 'management by intervention' with efforts to counter the disruptive effects of fire and drought. The desire to preserve the KNP landscape, and particularly the woody vegetation, led early rangers to attempt to restrict fires. Efforts were also made to counteract the destabilizing effects on game numbers

of the lowveld's frequent and often severe droughts – boreholes were sunk, and weirs and dams built in seasonal and later perennial rivers.

By the 1960s management by intervention had intensified to 'command and control' – a term given to the prevailing worldwide approach to natural resource management at the time. This highly interventionist management style was aimed at maintaining the 'balance of nature'. 'Balance of nature' thinking was central to ecology for much of the 20th century, and the notion of stable nature this portrayed was able to capture the imagination of a world beyond ecologists, a world which in large part continues to romanticise this condition today. Natural systems, in the absence of large-scale human interference, were believed to be internally regulated toward a stable or steady state. This was called a 'climax' or 'equilibrium' state and was recognised by the persistence of a characteristic type and structure of animal and plant communities over time. Though change was known to occur this was believed to be cyclic and predictable. Events termed 'disturbances', such as fires, floods or disease outbreaks, could reset the cycle – after which the system would recover along pre-determined paths toward its original, equilibrium, condition[5]. Pristine systems were predicted to be able to self-regulate toward this equilibrium but human-modified systems, such as fenced game parks, were proposed to require management aimed at maintaining the 'balance' or steady state. It was thought that this was best achieved by avoiding or controlling disturbances and the changes they brought about. In KNP this balance was thought to be represented by the type of vegetation observed around 1900, when the reserve was newly proclaimed.

By the 1950s and early 1960s sentiments were being expressed by biologists elsewhere in Africa that elephant populations should be controlled to prevent habitat change. The same concerns were voiced by biologists working in Kruger, who had noted a decline in large trees with increasing elephant densities. In November of 1965 a symposium convened by the National Parks Board, and attended by many South African biologists of the time, focused on the potential 'overprotection' of animal populations afforded by parks such as Kruger. One of the conference outcomes was the recommendation that the populations of seven species – elephant, buffalo, hippo, giraffe, wildebeest, zebra and impala – should be controlled by means of culling[6]. Various research outputs of the time were used to arrive at a recommended 'carrying capacity' and thus desired upper limit for Kruger's elephant population. A figure of 7000 elephants or roughly one elephant per square mile was supported by estimates from elsewhere in Africa and observations of the population density at which elephants in their favoured habitat in KNP began to disperse to populate the rest of the park. Starting in 1968, the culling of various species completed the picture of KNP as a highly managed system operating around the maintenance of a stable ecosystem state[7].

The culling of species other than elephant was eventually abandoned when it was realised that their populations followed predator-prey oscillations or wet and dry rainfall cycles. Elephant is the only species in KNP whose populations have not been shown to respond to short-term climatic cycles. Annual culling of elephant populations thus persisted through various review cycles of the KNP management plan. Between 1968 and 1995 this policy resulted in about 17000 elephants being removed from KNP, 2500 of which were live transfers to other conservation areas.

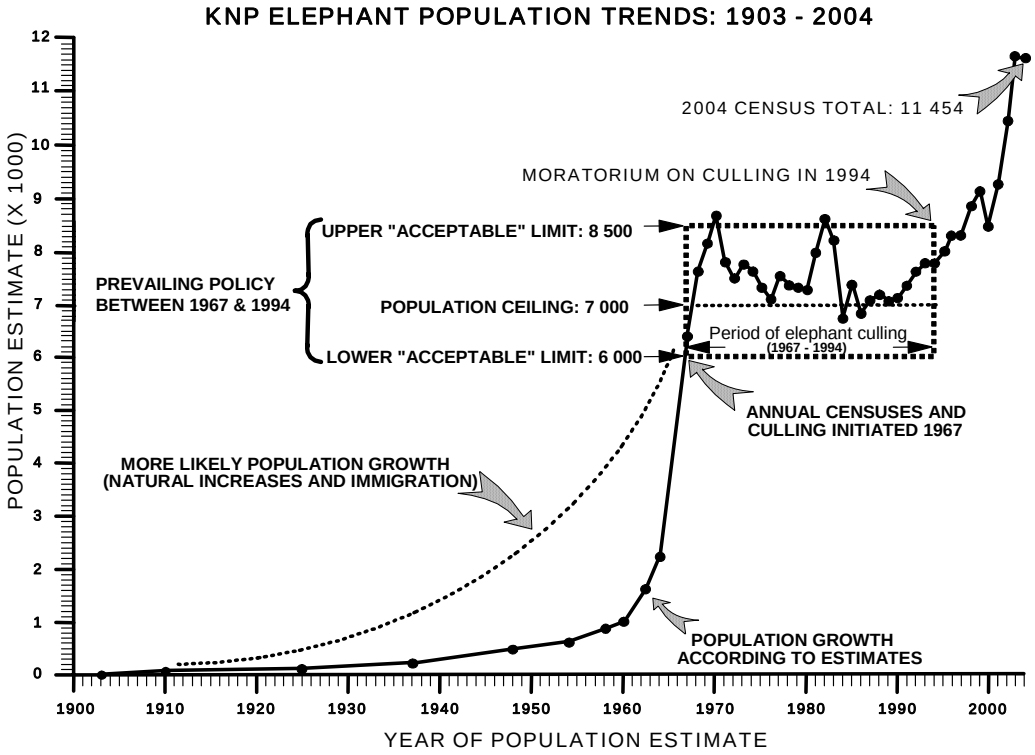

Figure 5: Growth of KNP's elephant population from 1900 to 2004

The present: Do we need to manage elephant impacts to protect the resilience of ever-changing ecosystems?

As management progressed in KNP and elsewhere, attempts to command and control ecosystems often had surprising and unwelcome consequences. Attempting to prevent fires, for example, merely led to a build up combustible material with fires eventually breaking out that were hotter and more damaging than those which had successfully been avoided. Rangers in KNP made this discovery early on and responded by introducing a programme of controlled burning to keep fuel loads down. As information from management accumulated, the details of management policies changed, though they still drew their underlying purpose and logic from equilibrium concepts.

At the same time the discipline of ecology was accumulating research findings that showed that in reality ecosystems are non-deterministic – their complexity, in the form of multiple feedback mechanisms, causes them to change in unpredictable ways and they are rarely stable or at equilibrium[8]. The apparent balance of nature was merely a snapshot that ecologists had taken of an ever-changing vista. Ecologists now realise that what they had documented in the past (and over the relatively short time period that the discipline of ecology had existed) was not the balance-of-nature but merely a small sample of what was really the **flux-of-nature**.

For example, in KNP we now realise that what managers of the past had aimed to preserve was not stable or in balance. The large stands of tall trees which left such an impression on early

visitors were established under conditions of very low herbivore numbers. This window of opportunity was created by the human impacts of hunting, particularly for ivory, and the introduction of rinderpest – an exotic disease. The vegetation at the time of KNP's establishment was thus not a reflection of the steady state of centuries, but a temporary condition which the spectacular recovery of herbivore populations since 1900 has now changed.

Over the long-term ecosystems can be seen to occur in a number of different forms. Most of the time these are simply a variation of the same fundamental state – e.g. a savanna with slightly different tree to grass ratios or dominant species. But ecosystems can also be driven to change more radically – e.g. a savanna may become a grassland or shrubland. If new feedbacks occur which act to keep the system in its altered state, this change could be irreversible. Previously, changes of these magnitudes were explained as an upsetting of the balance. Within the flux of nature paradigm ecologists now came up with the concept of **'resilience'**. Though ecosystems are constantly changing in response to various disturbances, drivers and external forces, and this overall change may be directional for a time, they seldom undergo a fundamental change in their basic character[5]. Resilience refers to this ability of ecosystems to absorb environmental stressors without undergoing an irreversible transformation in state.

Ecologists now believe that it is the existence of flux, variation and diversity that gives ecosystems their resilience in the face of extreme events. In other words, it is because they bend that they do not become brittle and break. Attempts to maintain the 'balance' by controlling or minimising fluctuations or extremes cause systems to become less resilient when faced with further stressors. The more we have tried to keep natural systems constant the more they have surprised us by changing.

Managing ecosystems under the flux of nature paradigm: resilience through diversity

The realisation of the flux of nature has required a fundamental rethink of the goals and methods of conservation and ecosystem management. Whereas previously managers attempted to dampen fluctuations in natural systems, the focus has now shifted to encouraging variation and variability, together referred to as **'heterogeneity'**. Heterogeneity implies the existence of patchiness in both space (different patches experience different environmental conditions and impacts) and time (individual patches experience changing conditions and impacts). Heterogeneity provides a diversity of patches in a mosaic – made up of different soil types, levels of mineral nutrients, water availability, heat, light and shade, hiding and nesting places, densities of herbivores, predators and disease. This patch mosaic provides habitats for many different organisms, and in this way contributes to maintaining biological diversity. **Biodiversity** is not simply the number of different species which occur in a particular area but includes variation at the level of genes, populations, species, communities and landscapes[9]. Three kinds of variation contribute to overall diversity: composition (what is there), structure (how it is distributed in space and time) and function (what it does and how it does it). For example, when considering the diversity of woody plants one can assess what species occur (composition), the number of trees in different size classes and where they are found (structure), and the role of different species and size classes in providing food, shelter, nutrient cycling, and erosion control (function).

Managing for heterogeneity and biodiversity requires a move away from simply monitoring and managing a list of species to the **explicit managing of ecosystems** by maintaining ecological

functions. Species are managed for their interactive roles in ecosystem functioning rather than their intrinsic value[10].

A key aspect of managing ecosystems to maintain ecological functions is that of **scale** – or the distances over which ecological processes and cycles play out in both space and time. The heterogeneity of a landscape occurs not at one scale but several. These patches at different scales can be described as being nested within each other e.g. patches of reeds within a wetland that occurs alongside other wetland patches on a floodplain – itself a patch in a coastal plain. A hierarchy of patches and scales is thus formed. Processes within patches at one scale contribute to patterns formed at higher levels and constrain patterns occurring at lower levels.

Patches, and the mosaic they compose, are **dynamic** – patches are destroyed or shrink in some places and are created or expand in others and thus appear to shift over time. The path of a river on a floodplain changes and a wetland on one bank dries up while on the other a new wetland patch is created. A severe fire removes a patch of trees from a savanna and for a time a patch of grassland persists in its place. This at once elegantly simple and challengingly complex concept is the basis of '**hierarchical patch dynamics**'[11] – the current theoretical framework of choice for landscape ecologists.

The distribution of plants and movement of animals within landscapes both responds to and creates the pattern of heterogeneity at various scales. Understanding the role and impact of various species and populations requires insight into the scale at which they perceive patchiness and thus use and influence their environment. For example, animals which undertake annual migrations may contribute to patterns at a global scale; long-lived, giant tree species are caught up in cycles and patterns spanning centuries. In the past conservation management was directed at a geographical and time scale convenient or accessible to managers. In the future effective management will depend on consideration of the hierarchy of scales, and the insight and ability to respond to problems at the scale at which they are created.

Managing ecosystems toward a 'desired state' reflecting societal goals

If ecosystems are ever-changing, then the desired outcomes of ecosystem management cannot be determined by science or history, but are value judgements. In the past managers valued historic conditions that were considered to be 'pristine' or 'natural'. Today, we acknowledge that ecosystems are valued by society for the services they provide – whether these meet physical, emotional, aesthetic, cultural or spiritual needs or desires. Alternative ecosystem states or conditions provide varying types and levels of ecosystem services which are valued differently by different people. Thus in democratic societies the goals of ecosystem management must reflect societal values and not merely those of scientists or managers – though recognising that we need to maintain the ecological processes on which our survival, and those of future generations, depends. In addition, many democratic governments have committed to a collective international vision to conserve our planet's biodiversity.

Recognition of the flux of nature has therefore created a number of new imperatives for ecosystem management: to achieve ecosystem conditions which meet societal needs (and to establish through a fair and just process what these needs should be); to protect ecological functioning; and to maintain the resilience of ecosystems and society through promoting heterogeneity and biodiversity. The unavoidable flux-of-nature also means that achieving these imperatives is far from simple.

Heterogeneity and resilience: a new context for the elephant management debate

What is the relevance of new paradigms of ecology and conservation for the elephant management debate?

Firstly, abandonment of the balance of nature view means that fixed carrying capacities, such as one elephant per square mile or 7000 elephants for KNP, no longer have any relevance other than a historic one. The appearance and composition of KNP's vegetation as it was first described by rangers in the early 1900s is no more 'natural' than that which currently exists. Given the severely depleted populations of all herbivores as a result of human impacts at the time of this vegetation's establishment, it is now understood to be quite 'unnatural'. But which level of canopy cover or tree to grass ratio is more or less natural is no longer up for debate, as the only detail described for ecosystems that is truly natural is change. What is unnatural is to attempt to hold an ecosystem in a particular form – nor is it possible or wise to do so. We can however attempt to maintain certain qualities and functions of a landscape, through promoting diversity and resilience.

Elephants are known to be major drivers of ecosystem change – both the type of change which generates heterogeneity, maintains diversity and enables resilience – and also the type of change which can ultimately cause ecosystems to lose diversity and resilience and thus undergo a fundamental alteration of state. Of most concern are the large geographic scales at which the shifting mosaic of elephant impacts most likely operated in the past. Similarly large time scales are known to be involved in the regeneration of woodlands. Ecological processes operating at scales of this magnitude are less likely to be possible now than they were in the past, due to shrinking areas of natural vegetation and confined elephant populations. This raises the question of whether our protected areas are large or diverse enough to allow elephant impacts to continue unchecked.

Finally, the desirability of different levels and risks of elephant impact are relative to the context and desired state of a particular ecosystem. Societal values must be brought to bear in considering these risks and goals.