CHAPTER 11: SYNTHESIS AND DISCUSSION

OF FORESTS, ELEPHANTS, AND MAN: A DELICATE BALANCE FOR THE CONSERVATION OF NORTHERN MAPUTALAND ON THE SOUTH AFRICAN - MOZAMBICAN BORDERLAND

Abstract

The conservation of the rare, diverse and valued vegetation of Maputaland, a region shared by South Africa and Mozambique, is investigated. Conservation options within areas under formal and informal protection, as well as within a human-dominated landscape are discussed after a short review of recent studies on the ecology and social aspects of the region. Animals and people have been the drivers of some major vegetation changes observed within the past 15 years and it is clear that the increasing utilisation pressure by these agents will soon lead to the loss of species, habitat and processes. However, results from a control area that has not been utilised by either agent in a similar time span also show that the influence of animal and human disturbance is an essential component of the northern Maputaland vegetation. Because most-tourist attracting mammalian species in conserved areas do not have threatened status on a global scale, it appears clear that conservation in the region should prioritize vegetation processes across the various landscapes and land-uses and options for unconventional conservation methods are evaluated and discussed. Non-tourism based conservation targets of sometimes-controversial social acceptability such as culling, carbon trade, and developing agro-forestry landscapes appear most likely to ensure that vegetation subsistence conservation targets would be met.

Keywords

Agro–forestry, conservation, elephant, Maputaland, Sand Forest, tourism, utilisation, vegetation

Introduction

In Maputaland as elsewhere in Africa, the processes that govern ecosystem maintenance are at risk from a growing human population (Laurance 1999; Matthews 2006). Until recently, Maputaland remained a little explored region, known for its richness in biodiversity (Van Wyk 1996; Van Wyk and Smith 2001; Smith *et al.* 2006). This diversity was thought to be significantly conserved in the network of parks and reserves in Maputaland (Van Rensburg *et al.* 2000b; Van Wyk and Smith 2001), but recent evaluation of the success of conservation management of mammals in

Maputaland suggests that large herbivore populations are reaching densities that endanger habitat maintenance and diversity governing processes in similar ways as people (Morley 2005; Botes *et al.* 2006; Guldemond 2006). The organisations charged with the management of conservation areas have therefore reached a stage where informed decisions need to be made and management actions should follow suit. Based on a synthesis of current ecological knowledge from recent studies in the region and that gained in the present study, the challenges that lie ahead are explored and some solutions discussed.

A review of results from recent studies on the ecology of Maputaland

1) Conservation planning

A suite of studies based on Geographic Information Systems (GIS) have classified the region as a conservation priority in South Africa. These studies have also noted that human pressure is likely to jeopardise the conservation of ecological processes in the near future (Eeley *et al.* 2001; Reyers *et al.* 2001; Reyers *et al.* 2002; Jones 2006; Smith *et al.* 2006). The main identified threat was the large and unutilised tracts of land available because traditional subsistence farming has proved unsuccessful, but where the soils lend themselves to technologically-aided modern agricultural practices (e.g. drip irrigation) unavailable to the rural and poor majority of the population. Such modern agricultural practices could prove economically more viable than conservation and would result in forest clearing and fragmentation to open fields for mechanised and irrigated agricultural practices as observed elsewhere (Boltz *et al.* 2001; Muchagata and Brown 2003; de Barros Ferraz *et al.* 2004).

2) Vegetation

A set of phytosociological studies evaluated the floristic composition of three sites in northern Maputaland namely Sileza Nature Reserve (SNR) (Matthews *et al.* 1999), Tembe Elephant Park (Tembe) (Matthews *et al.* 2001) and Tshanini Community Conservation Area (Tshanini) (Gaugris *et al.* 2004). The former two studies concentrated on areas conserved by the conservation authorities of the KwaZulu-Natal province of South Africa and subject to animal utilisation, while the latter one investigated a community-based conservation initiative subject to no utilisation. The three studies presented an assemblage of woodlands and Sand Forest, remarkable in floristic similarity. However, further analysis of dung beetle and avian assemblages in terms of patch variation revealed a great disparity in the species composition between patches (Van Rensburg *et al.* 2000b), thereby requiring conservation on a larger scale to preserve the ecosystem processes within these vegetation communities. Comparisons between Tembe and Tshanini revealed that species composition was remarkably similar, but species abundance was assumed to have changed due to the effect of large herbivores in Tembe. However, it appeared difficult to ascertain where the most representative original vegetation state lay, as both sites have been submitted to treatments that differed from the natural state that prevailed before demographic pressure and animal extirpation changed the conditions.

Based on a synthesis of the studies in Tembe and SNR Matthews (2006) presented several hypotheses regarding Sand Forest. He suggested that Sand Forest was a community in stasis as a result of meteorological conditions that have prevailed over the past 1 800 years and was only able to sustain itself as long as it remained undamaged. Sand Forest grows in mist-prone areas on self-modified hydrophobic soil. Moreover the hypothetical allelopathic characteristics of the Sand Forest compounds found in the soil could preclude the development of a conspicuous ground layer. The majority of plant species disseminate by fleshy fruits, most likely animal dispersed, while woody species of Sand Forest appear to grow older than woodland woody species. The most likely origin of Sand Forest is that its precursor is Dune Forest, which subsequently evolved in a separate functioning system with a different species composition to become the present day Sand Forest (Matthews 2006).

Two other phytosociological studies investigated the vegetation of Maputaland further south. One concentrated on a flood plain system and found that the vegetation communities were arranged along an inundation-sedimentation gradient (Patrick and Ellery In Press). The other study evaluated the grasslands and woodlands of northern Maputaland north and east of Mkhuze Game Reserve in the Makhathini flats plain but disregarded the forests (Morgenthal *et al.* 2006).

Wooded grasslands of Maputaland are the other most exciting vegetation type of Maputaland and are described as the evolutionary result of a fire controlled system (Matthews 2006).

A study in southern Mozambique described the vegetation of the Licuati Forest Reserve. The presence of a thicket-like vegetation that rarely exceeds 5 m in height, called Licuati Thicket and that of a taller vegetation called Licuati Forest were recorded. These two vegetation types have been identified as equivalents to the vegetation types previously called Short and Tall Sand Forest in South Africa (Izidine *et al.* 2003).

3) Human plant utilisation

Plant utilisation by people in rural and unprotected areas has been highlighted as a concern and several studies have identified and quantified utilisation by local people in an effort to provide information to develop management plans for their sustainable utilisation. One such study evaluated the influence of reed harvesting on reed bed quality in the Muzi Swamp (Tarr *et al.* 2004). An aspect of the results suggested that harvesting should be limited to the dormant winter period in order to allow nutrient reserves to be transferred to the rootstock in the late summer. Harvesting for firewood, crafts, medicinal purposes and building wood have also been evaluated. One study concentrated on areas along the main road that links the towns of Ingwavuma and KwaNgwanase and found that surprisingly few signs of utilisation were visible. Removal was mostly for local purposes and utilisation decreased significantly along a gradient away from villages (Brookes 2004). An in-depth study evaluated the amount of wood used for household buildings. It was estimated that the harvesting needs of 800 people in a rural community for the eight years following study in 2004 would be at least 28 147 wall laths, 1 416 roof laths, 628 main posts, and 477 main beams per year (Gaugris *et al.* 2007). The potential to develop a finished product to sell with added value, through assembling prefabricated wood and reed hut panels by using surplus reed and wood harvest available was also investigated (Tarr *et al.* 2006).

Several studies of a more sociological nature have evaluated the value of natural resources for rural people of the region and showed that while there were clear signs of modernisation of society in northern Maputaland, the utilisation of natural resources in the region was essential to the survival of rural families (Kloppers 2001; Kloppers 2004; Peteers 2005).

4) Effects of animals on vegetation

The African elephant *Loxodonta Africana* (Blumenbach 1797) population of Tembe was estimated, using scientifically accepted methods, at 179 individuals in 2004, with a confidence interval allowing for a range of individuals from 136 to 233 (95% confidence interval) (Morley 2005), and estimated to grow at 4.64% per year since 1989. A study on elephant impact at the micro-, meso- and macro-scales was conducted in and around Tembe (Guldemond 2006). This study established that elephants had an effect at the micro-scale by increasing the heterogeneity of closed woodlands but homogenising open woodlands. There was little effect at the meso-scale when comparing communities inside park and outside the park, while at the macro-scale levels, elephants did not appear to follow a landscape selection pattern. A study on elephant movement patterns across Tembe showed definitive routes within the park, and that elephants created themselves refuges in the Sand Forest and created canopy gaps in doing so (Shannon 2001). A study on smaller herbivores documented the plant species preferences of these animals and some aspects of their ecology in Maputaland inside and outside conserved areas (van Eeden 2005). Studies using dung beetles and birds as indicators of elephant or human impact inside and outside Tembe revealed a significant influence of both agents in reducing the diversity of these indicators (Van Rensburg *et al.* 1999; Van Rensburg *et al.* 2000a; McGeogh *et al.* 2002; Botes *et al.* 2006).

A synthesis of insight gained from the present study

In the present study some hypotheses on the ecology and dynamics of Maputaland are revisited. For the most part, previous hypotheses were not substantiated by quantitative data, whereas the present study is possibly the first to provide quantitative data whereby our insight into the dynamics of the region's woodlands and forests can be advanced. The analysis of the functioning of these ecosystems is further strengthened by investigating the systems on their own and under the influence of mammals or people. The aspects revealed by the present study are summarised and discussed in their context.

1) The Sand Forest diversity in structure and woody species assemblages

Sand Forest remains a largely unknown and unexplored vegetation type. The present study re-defined the groups of Tall and Short Sand Forest by separating them through a newly interpreted Intermediate Sand Forest subcommunity. The evidence obtained from Tembe defined three communities at the floristic and structural levels. However, considering the ordination of these communities with their counterparts in Tshanini revealed that a larger number of units should be considered, as the Short Sand Forest of Tshanini (Gaugris *et al.* 2004) was remarkably different from the Tembe one and might be more related to the Licuati Thicket defined by (Izidine *et al.* 2003) in Mozambique, where trees were rarely noted to emerge from the 5 – 6 m thicket-like canopy.

The implications of the present results are numerous. It appears that Sand Forest is definitely a more complex and possibly dynamic system than has been believed until present. The variations in the forest have been described before at the species level (Matthews *et al.* 1999; Van Rensburg *et al.* 2000a; Van Rensburg *et al.* 2000b; Matthews *et al.* 2001; Izidine *et al.* 2003; Matthews 2006), but the distinctions in structure are new and lend themselves to debating the fact that Sand Forest could be a mosaic of different stages of the same vegetation type, represented by the dominance of different species guilds and structural features (Whitmore and Burslem 1996; Burslem and Whitmore 1999). Another implication is that Sand Forest, although apparently static in size over the past 50 years (Matthews 2006), is actually a diverse, active and self-sustaining vegetation type that derives its exceptional diversity from the mosaic of patches at different structural stages representing successional pathways between one structure and another (Burslem and Whitmore 1999). This runs contrary to hypotheses presented so far.

2) The state and dynamics of woodlands and Sand Forest under different utilisation regimes

The horizontal and vertical structure of similar vegetation units in Tembe, Tshanini and the Manqakulane community village area (Manqakulane) were evaluated in terms of size class distributions and centroid locations. All vegetation units within sites where human (Manqakulane) and animal (Tembe) utilisation have prevailed since 1990 showed evidence of active regeneration possibly stimulated by canopy gaps and an increased light continuum, while in Tshanini regeneration appeared reduced and the understory was more typical of a closed canopy situation in the woodlands. It is hypothesised that the observed differences are the results of 15 to 30 years under different land-use.

A species level analysis of the same vegetation units revealed that the majority of woody species evaluated had relatively steep slopes and a minority of larger trees had shallower slopes. The results indicate an overall good to excellent regenerative potential with exceptions for some species that appear to have been eliminated by utilisation through a particular agent, most notably the *Albizia* species and *Sclerocarya birrea*. This analysis revealed that woody species populations appeared more mature in Tshanini than in Tembe or Manqakulane, although there were not enough large trees to completely fulfil the criteria for mature populations. Moreover and contrary to previous findings, fine-grain processes appear to lead the dynamics of the region's woodlands and forests. These processes are dominated by non-gap-demanding processes or by the creation of small-scale gaps on a relatively frequent basis that maintain species diversity and regeneration. It appeared obvious that while animals and people played a role in maintaining these vegetation units in the past, however, the current utilisation pressure by either agent was likely to jeopardise the vegetation condition as patterns of utilisation become more characteristic of larger scale disturbance suitable for coarse-grained forests. The absence of disturbance was identified as provoking a change towards coarser grain in Tshanini, but it may also be one of the potential requirements for succession from woodland to forest to happen.

The present study represents the first large-scale vegetation study that investigated the abundance and distribution of woody species in this region of Maputaland and attempted to offer some insight of its dynamics. Previous studies relied on much smaller sample sizes (Matthews *et al.* 1999; Matthews *et al.* 2001; Gaugris *et al.* 2004; Gaugris and Van Rooyen In Press) and did not detect as many nuances in the region's vegetation. The current study, although it reveals many more facets to the northern Maputaland vegetation, remains incomplete, as long-term studies on the growth and mortality rates are essential to obtain a more in-depth view of the overarching dynamics (Condit *et al.* 1998). Nevertheless, the results indicate many aspects that run against hypotheses presented before. The most controversial issue remains the fact that Sand Forest now appears as a dynamic, regeneration prone unit that is intricately linked to the presence of a disturbance agent for the maintenance of its diversity and regeneration processes.

3) The impact of animals and people

The impact of the utilisation of vegetation by people and animals in Maputaland has been debated over the past 10 years and while a general consensus has recently been reached that both agents now have a negative effect on vegetation dynamics (Matthews 2006; Morley 2005; Botes *et al.* 2006; Guldemond 2006), the present study is the first attempt at quantifying these effects. Utilisation was mostly in the form of canopy removal by a range of animals and people, associated with what has been referred to as natural damage. The numbers of woody species used by these agents in their respective areas of influence were high. For elephants and natural damage scars appeared to accumulate, and a new element identified was the observation of utilisation / canopy removal for all woody individuals within a range of height classes. In Tembe it was established that elephants open the canopy while smaller mammals slow down regeneration, thus increasing the grass layer, especially in woodlands, and therefore increasing the influence of fire. This could lead to a "classical" woodland to scrubland to grassland successional progression, typical of abnormally high animal densities in restricted areas such as was observed in East Africa 20 to 30 years ago (Western and Maitumo 2004). In Manqakulane a similarly intense canopy removal by people was established, leading to a somewhat similar successional pathway. Finally, a study of elephant mean utilisation levels over a recent and old period showed active landscape selection in relation to a distance to water gradient during the recent drought years of 2004 and 2005.

The results of the present study corroborate hypotheses proposed in other studies (Van Rensburg *et al.* 1999; Van Rensburg *et al.* 2000a; Matthews 2006; Botes *et al.* 2006; Guldemond 2006), but more importantly indicate that intensely disturbing patterns observed elsewhere in Africa (Walpole *et al.* 2004; Western and Maitumo 2004; Colón and Lugo 2006; Karlowski 2006) are activated and likely to develop fully in Maputaland should no management action be taken. The implications for the conservation authorities are straightforward as these effects have been observed elsewhere in Southern and Eastern Africa, but solutions have also been found and proven successful.

To conclude, the main point in the present study was the documented proof that Sand Forest and Woodlands of Maputaland are active vegetation groups, and that their biodiversity is linked to animal and human agents. However, the survival of these biodiverse ecosystems is dependent upon limiting the repeated large-scale effects of people outside conserved areas and herbivore mammals, especially elephants, in conserved areas. Considering that most large herbivores in Tembe are not in immediate danger of extinction and are well represented within South Africa by a host of other equally or more numerous subpopulations, the present study suggests that the conservation of the vegetation should become the priority for the Tembe management team.

Sand Forest and Woodland dynamics and their management

Most studies to date would question the Sand Forest as described in the present study because it was seen as a vestigial remnant of a long gone era when climate was wetter and more propitious to its expansion (Van Rensburg *et al.* 2000a; Matthews 2006). Most observations by prior studies indicate that Sand Forest does not regenerate after large scale disturbance and that woodland and Sand Forest similarities in species composition and even sometimes structure are the result of a unidirectional change from a forest to woodland state (Van Rensburg *et al.* 2000a). The implications of such a successional pathway imply that forest loss is irreversible under present conditions.

A rapid look at human and animal presence in the region is needed before discussing the implications of the above and the present study further. Organised human presence in Maputaland is well-documented for the period from 1502 until present (Kloppers 2001). The presence of people prior to this date is certain, although much less is known about it (Kloppers 2004; Matthews 2006; Peteers 2005). It is believed that iron age communities populated Maputaland as early as 290 AD, while signs of human presence date back from 110 000 years (Peteers 2005). The animals of the region have been hunted by people for as long as their presence in the region has been documented (Kloppers 2001; Peteers 2005). The human and animal presence in Maputaland therefore represents a very long association of these two agents with the vegetation of the region. Such long-standing associations are known to have interrelated effects, especially the shaping of vegetation by uninterrupted human societies over a long period of time (Ickowitz 2006). In such human-dominated rural societies the progression from forest to woodland or woodland to forest have been documented over history (Ickowitz 2006). The present state of most west, central and east African wooded landscapes appears to be 1800 – 2000 years old, and wherever paleo-palynologists, archaeologists and biologists have worked together, there is mounting evidence that human societies have shaped the advance and retreat of forests and woodlands during this era (Ickowitz 2006). Due to the long-term presence of people in Maputaland it appears doubtful that they would not have had such a shaping influence, especially considering that fire appears to have been a management tool since early ages (Matthews 2006; Peteers 2005).

Due to the implications of such long-term interactions affecting ecological processes that span centuries to millennia (Whitmore and Burslem 1996; Chapman *et al.* 1997; Burslem and Whitmore 1999; White and Jentsch 2001) statements regarding current (50 – 100 years prior to study time) woodland to forest or forest to woodland successional pathways in Maputaland as inferred by the studies referred to above should be done with caution. However, what appears undisputed is that animals and people have been and remain part of the dynamics of the region's vegetation and should probably not be separated from the system.

The consequences of the fine-grain character have been discussed in the relevant sections, but a further interest is that managers need to focus on guaranteeing a level of disturbance that allows patches of vegetation to be utilised and recover thereafter. The implications for such management are most likely limiting the number of animals in conservation areas, and creating and thereafter controlling a rotational harvesting system for human utilisation. Defining the levels that promote fine-grain processes remains unknown for Maputaland conservation. However, the present study has clearly established that current levels are untenable and are promoting changes that are considered undesirable for the conservation of the vegetation in Maputaland. Therefore, it is suggested that the 2004 population of 179 elephants in the 30 000 ha of

Tembe (Morley 2005), the numbers of other herbivores for 2004 in Tembe and 778 people in 124 households on the 2 500 ha of Manqakulane for 2004 (Peteers 2005) most likely represent values that exceed the threshold for maintaining the region's vegetation dynamics. These densities of agent per ha or km^2 could be included into conservation planning systems as indicators of forced forest to woodland to grassland succession (Smith *et al.* 2006).

Because the above values indicate undesired problems in the making, it is logical to accept that either lower animal numbers or restricted human access to resources is required. Setting these numbers will be a difficult task, as the conflicting interests of tourism and conservation (Matthews 2006) will have to be considered in conserved areas while those of people's needs and conservation's needs will need to be taken into account in non-conserved areas (Gaugris 2004; Gaugris *et al.* 2007).

Because the three sites studied have been under their respective agent's influences for known periods, it can be assumed that the differences observed are the results of a minimum of 12 years influences or lack thereof in Manqakulane and Tshanini or 15 years for Tembe. These values are absolute minimums and are most likely not representative of the real time span, which is probably closer to double these values. In effect animal populations' movements in this area of northern Maputaland were confined within Tembe since 1983 (Matthews 2006), while since 1975, people from the Manqakulane community already utilised the Manqakulane area before they settled there permanently in 1992 (Peteers 2005). The changes observed are therefore most likely derived from a period of 21 – 29 years influence of the agents. The situations observed in the present study represent the end results of a succession of elements and their accumulated effects over a period that spans approximately a quarter of a century. It appears likely that the success of direct conservation measures in Tembe and by default conservation measures in Tshanini and its implied restrictive effects for Manqakulane since the 1989 – 1992 timelines have exacerbated the progression towards its current state. It appears also likely that recent increases in animal densities in Tembe and in human population in Manqakulane could have had exponential effects on the vegetation. In this situation, it may be that only the past five to eight years represent a problem timeline. However, for reliability, the above-defined 12 – 15 years timeline should rather be considered as the accurate reading.

As a guideline it would be recommended to investigate the animal numbers of Tembe from the selected timeline as a threshold that management actions should possibly consider as non-damaging to vegetation dynamics of the region. The elephant population in 1989 was estimated to have ranged from 124 to 152 individuals (or 0.41

to 0.50 elephant km^{-2}) (Morley 2005), which is significantly more than presented in previous other studies (Klingelhoeffer 1987; Matthews and Page In Prep). These studies were considered inaccurate due to the bias of Tembe's elephant population in favour of bulls, which was established during the most recent study (Morley 2005). The human population in Manqakulane at that time is unknown. However, the population is thought not to have changed significantly since 1996 due to emigration towards main access roads (Peteers 2005). An educated approximation would therefore place the population of the community between 250 and 500 people. The animal numbers from this period in Tembe are documented by regular large herbivore estimates undertaken by the regional ecologist of Tembe (Matthews 2000). The report available to the present study made clear that surveys were conducted in 1990 and 1994. Animal population estimates from these reports should probably be used to determine and re-evaluate thresholds of animal densities for Tembe.

A further note on elephant impact concerns the accumulation of scars on the woody species. Such scars due to elephant utilisation have been documented in other studies and the repeated scarring often led to the death of many woody species utilised (Conybeare 2004; Sheil and Salim 2004). A similar study in Tembe, conducted in 1995 did not note the level of scarring as in the present study (Matthews and Page In Prep) and it appears highly likely that should scars have been present, it would have been recorded and discussed. It is therefore assumed that the study by those authors reflected a situation that would not have harmed vegetation processes and reinforces the opinion that animal numbers from the 1990 – 1992 timelines should be seriously considered as optimal management guidelines to ensure the persistence of vegetation. It is important to realise that based on the present study's results and deductions, the above number of elephants from the 1990 – 1992 period is suggested as a threshold that ensures vegetation persistence and not as the ecological carrying capacity of Tembe for elephants. Recent studies (Morley 2005; Guldemond and Van Aarde In Press) show that elephants in Tembe have yet to reach the level of density-dependent regulation of the population assumed to represent the ecological capacity of the system for this agent (O'Connor *et al.* 2007). It is interesting to note that the above number of elephants represents an animal density of 0.41 to 0.50 elephant per km^2, which is remarkably close to the density responsible for density-dependent auto-regulation assumed to be active in Kruger National Park in South Africa (0.374 elephant per km^2) (Van Aarde *et al.* 1999). However, several flaws plague the auto-regulation concept, not least of which are that self-regulation mechanisms remain highly hypothetical (O'Connor *et al.* 2007). Another facet is that self-regulation is most likely linked to rainfall and food availability (O'Connor *et al.* 2007), both of which are much higher in the Maputaland region than in the Kruger National Park. Finally another problem with keeping an elephant population as close as possible to a static predetermined number is that it is not desirable (Van Aarde and Jackson 2007) because it opposes the non-equilibrium principle now accepted to rule African savannas. Some implications and solutions for this particular aspect are discussed in the next section.

The level of accumulated canopy removal observed and considered as scars in the present study begs the question of defining a boundary between utilisation and damage. The fact that signs of utilisation accumulate suggests that insufficient time is available between utilisation events to allow the recovery of the plants affected. In an open ecosystem, such accumulation of utilisation events may be observable over a short period, but the intrinsic quality of the system allows the animals to move to a different area as soon as any of their food selection criteria are no longer met (O'Connor *et al.* 2007). The likelihood of a return to an area that was previously utilised is low when sufficient habitat of suitable quality is encountered (O'Connor *et al.* 2007; Van Aarde and Jackson 2007). In the areas defined as closed systems due to fences or anthropogenic pressure, where such free-ranging is by definition excluded, and where utilisation accumulates to form scars (Van Aarde *et al.* 1999), it appears important that the notion of damage to the vegetation should supersede that of utilisation of the vegetation. The Oxford English Dictionary defines damage as “physical harm reducing the value, operation, or usefulness of something”. In the context of Tembe the above definition appears fitting as it seems that utilisation of the vegetation is reducing the value thereof. It is therefore suggested that conservation authorities should thrive to eliminate damage of the vegetation.

Conservation and the elephant question in the Transfrontier context

A transfrontier conservation area (TFCA) agreement has been signed between Mozambique, Swaziland and South Africa for the creation of the Lubombo TFCA. The planned development of this project is to re-establish a wildlife corridor (Futi Corridor) between the Maputo Elephant Reserve (MER) in Mozambique, Tembe and Ndumo Game Reserves in South Africa and Swaziland’s Hlane National Park and Mlawula and Ndzinda Game Reserves (Kloppers 2001). The most influential aspect of this linkage would be to allow elephant populations of Tembe and MER, estimated to represent 384 individuals in total in 2004 (Morley 2005), to roam freely in a landscape approaching 180 000 ha for the MER – Futi Corridor – Tembe system. The size of this system would certainly guarantee a gap in time before elephant populations have increased to a degree that once again threatens the ecology of northern Maputaland. Assuming the lower density option as recommended above by the present study (0.41 elephant km^{-2}) based on Morley's (2005) results and the upper growth rate described for these populations of 4.64% per year (Morley 2005), a period of 15 to 16 years appears necessary to reach the recommended lower limit, calling for an elephant population in the 700 to 800 individuals for the system. Due to the greater diversity of environments offered by the larger system, it may be possible that a greater density of elephants could be supported before vegetation becomes damaged. Nevertheless, while these estimates remain over-simplistic, the problem remains the same as the larger conservation area thus created remains a closed system, and effects are only delayed by 15 – 30 years depending on the pathway chosen.

The further opening of this greater system towards yet another conservation area is an appealing option for the conservationist mind. Such an option would necessitate corridors to be opened between the conserved areas as well as active protection. Alternatively, such linkages could be acting as sinks and conserved areas acting as sources, as implied in the southern African global elephant metapopulation framework (Van Aarde and Jackson 2007) However, some aspects need consideration before further discussing the issue.

The first issue is one of economic feasibility and desirability. Southern Mozambique, especially the region around the capital city of Maputo and the N4 highway that links Johannesburg and Pretoria in the Gauteng province of South Africa, is an economically active region that has an undeniable attraction for Mozambican people searching for employment opportunities (Kloppers 2001; Kloppers 2004). It is expected that the renewed interest in Maputo as a major harbour for the Indian Ocean coastline, and the agricultural potential of the inland area will provoke a considerable influx of people along an east – west axis from Maputo towards Komatipoort, the South African borderpost on the N4 highway (Kloppers 2001; Kloppers 2004). This highway is of particular economic importance as it links the harbour of Maputo to the economic powerhouse of South Africa, namely the cities of Johannesburg and Pretoria. It is therefore most likely that within the 15 – 30 years timeframe considered, this development axis will represents a real barrier to the development of a wildlife corridor that would link the Kruger – Gaza – Gonarezhou TFCA shared by South Africa, Mozambique and Zimbabwe to the Lubombo TFCA. Such an economic development would probably negate any wildlife corridor linkage possibility in the short- to medium-term future (15 to 50 years) as it appears doubtful that politicians of developing countries would limit their options in one of the most economically favourable areas of the country (West and Brockington 2006). The only way such a linkage would succeed would be to prove that economic benefits from the wildlife corridor would exceed the economic value of development in the region (Cairncross 2004), which appears unlikely.

Should such a wildlife corridor be developed, another issue lies in controlling the safety of people and wildlife through such a human populated landscape. Elephants and other wildlife avoid human populated areas (Walpole *et al.* 2004; Banda *et al.* 2006; Buij *et al.* 2007). In the absence of guaranteed security throughout the wildlife corridor, wildlife movements through the corridor will be reduced to such a low level that the desired effects of density reduction are unlikely to be achieved. Indeed some wildlife will be lost to the sink represented by the corridor. But wildlife reaction to such hunting in other parts of Africa (Hall *et al.* 1997; Maisels *et al.* 2001; Buij *et al.* 2007) suggests that the desired elephant metapopulation ideal, that of a sink harvesting equilibrating the growth from the source population (Van Aarde and Jackson 2007), would not be reached, and therefore the source population would most likely continue to grow. In addition, what is needed for wildlife is equally necessary for people and guaranteed human safety from wildlife needs to be ensured (O'Connell-Rodwell *et al.* 2000) while crop safety and crop loss compensation needs negotiating (Naughton-Treves 1998; Schmidt-Soltau 2003). The short- to medium-term implications of such a corridor in this part of southern Africa imply an “old style” preservation of the link between two conservation areas by fencing in potentially valuable land (O'Connell-Rodwell *et al.* 2000), to the detriment of local rural people (Kameri-Mbote and Cullet 1997; Perrings and Lovett 1999). The term for advocating such a system without favourable and immediate economic return is called “political suicide” (Christensen 2004b; Christensen 2004a).

From the above it appears therefore unlikely that a wildlife corridor would be established in the near future to connect the Lubombo TFCA to another conservation system further north. Another two options of enlarging the system should be investigated. One consists in opening Tembe towards Tshanini, and creating a larger community run concession-like area south of Tembe. This option affords a widening of the system by 10 000 to 20 000 ha before land valuable to people and densely settled zones are encountered (Patrick and Ellery In Press; Smith *et al.* 2006). The short- to long-term attractiveness and value of this option for vegetation subsistence and the wildlife management point of view appears rather low. The second option consists of linking the MER to the Maputaland Coastal Marine Reserve and the St Lucia Wetlands Biosphere Reserve along the Indian Ocean coastline in South Africa. However, similar problems will be encountered with this option as those described above with the presence of the towns of KwaNgwanase in South Africa and Ponta de Ouro in Mozambique in economic expansion and presenting a serious obstacle if not quite as considerable as the one considered above.

This review of options for further expansion shows that intrinsically the Lubombo TFCA may become a closed system in the near future, and failure to consider this aspect will lead conservation authorities to encounter the same problems as today, but at a larger scale, within 15 to 30 years. An option to consider lies in the creation of botanical reserves within the conserved areas (Lombard *et al.* 2001). Although the concept is attractive, the most efficient way to ensure the long-term effect of such reserves lies in adequate elephant-proof fencing (O'Connell-Rodwell *et al.* 2000). The Tshanini situation probably corresponds most closely to a botanical reserve, and while the vegetation is undoubtedly in excellent condition (Gaugris *et al.* 2004), the absence of elephants and other mammals does not appear as the panacea. The direct implication means that regular changes of the botanical reserve boundaries would be needed to ensure that the required disturbance level is reached for most patches. Fencing is not aesthetically pleasing, is ecologically debatable, represents a considerable economic cost to establish and maintain subsequently (Borrini-Feyerabend 1997), but more importantly in this case it does not solve the core issue of the problem. In the Lubombo TFCA context, the use of botanical reserves is therefore suggested as one tool to limit elephant impact on vegetation if needed, but its cost should be carefully considered and weighed against the cost of measures that are more likely to solve the problem. Similarly, long distance translocation is not considered, because it has little value for rural communities, because most southern African conservation areas have reached saturation, and because prospects for translocation further north in Africa are prohibitively expensive as well as unethical because the safety of the animals could be less than adequate (Van Aarde and Jackson 2007). However, short distance (highly localised) translocation is discussed further below.

Solutions to the problem are therefore most likely to be found in a population control method. Because levels of density-dependent auto-regulation of the elephant population are not obvious and remain to be established, even for systems of a much greater size than considered here (Van Jaarsveld *et al.* 1999; O'Connor *et al.* 2007; Van Aarde and Jackson 2007), it seems most unlikely that auto-regulation mechanisms of the MER – Futi Corridor – Tembe elephant population would be stimulated by a population size of 700 to 800 individuals. The option of managing the southern African global elephant population as a metapopulation makes allowance for using the elephant locally as a resource, pending that its conservation is assured through the metapopulation concept elsewhere in the subcontinent (Van Aarde and Jackson 2007). It is the resource aspect that appears the most promising in the current context.

Rural communities need to benefit from conservation in order to ensure continued support for conservation action. This definition, although very simplified and wide, represents the essence of conservation objectives since the era of “old style” preservationist policy has been considered politically inappropriate (Wilkie *et al.* 2006). As such the use of wildlife in general, and elephant in particular, needs to benefit neighbouring communities in a significant way. Wildlife population reduction can be achieved through culling, hunting, and contraception. The latter has been described as viable for small populations on limited areas where repeated treatment is economically feasible, but the long-term consequences on treated animals’ behaviour is unknown (Van Aarde and Jackson 2007). Moreover, contraception is an expensive means of controlling wildlife populations that can hardly be presented as a benefit for neighbouring rural communities.

Culling and hunting are therefore the two most likely options. Both of them are fraught with social controversy (Van Aarde and Jackson 2007), but benefits from such activities are undeniable (Chardonnet 1992) and costs can be relatively limited once a proper structure has been established (Schmidt-Soltau 2003). One of the most criticized issues of these activities lies in the concept of reducing wildlife populations towards a set number of animals. As a starting point, conservation authorities need to accept the underlying condition that because elephant management is within a metapopulation framework, the loss of the isolated and small Tembe and MER regional subpopulations (O'Connor *et al.* 2007) does not represent a threat to the conservation of elephants on the southern African subcontinent as much larger subpopulations (>2000 individuals) exist and are increasing (Morley 2005; O'Connor *et al.* 2007; Van Aarde and Jackson 2007). Moreover, according to several viability studies, the Tembe and MER subpopulations are below the recognised threshold for long-term genetic maintenance (Van Jaarsveld *et al.* 1999; Sanderson 2006) of elephant populations (> 500 individuals) and their loss does not appear critical. However, it is relatively easy to maintain genetic diversity through exchanges between subpopulations (Morley 2005). Loss of the subpopulations is not contemplated in the present case, but it was deemed important to highlight their relatively unimportant status and further justify the possibility to utilise the population for other purposes.

The scientific and economic issues with the culling of elephants in the Kruger National Park in South Africa during the period from 1967 to 1996 were mostly linked with population dynamics disruption, the stimulation of population growth, the creation of static population numbers, and finally the economic cost of logistics to cull and process in excess of 17 000 elephants over that period of time (Van Aarde *et al.* 1999; Van Aarde and Jackson 2007). However, the main difference with the Tembe and MER subpopulations is that the scale of the subpopulation is nowhere close to that of Kruger National Park, and that in Tembe vegetation conservation has been considered more important than elephant conservation. In the following section the discussion concentrates on the Tembe population, as the Tembe and MER systems are not yet linked. Bringing the Tembe elephant population down to its 1990 level represents the culling/hunting of approximately 100 individuals. This number can be hunted (marketing of bulls) / culled (family groups) relatively easily in terms of logistics (Chardonnet 1992), and its economic processing including the sale of hunts and the sale of meat and elephant derived products will most likely offset the initial costs over a short to medium term timeframe and offer an added economic incentive, yet absent (Chardonnet 1992). Elephant population fluctuations at the scale of Tembe are probably limited to the 50 – 200 individuals range within 30-year cycles while for the MER – Futi Corridor – Tembe scale, the range of fluctuations could be allowed between 100 and 800 individuals within 40 years. At these scales it would be worthwhile evaluating whether such variations may be identified as large scale temporal variation that in principle follow the non-equilibrium theory, while at the same time conserving the system's vegetation.

The acceptability of such practices has been debated recently with regards to tourism appeal. Tourists want to see large herbivores, and it appears clear that thresholds of tourism appeal need to be considered. The combination of forests, woodlands, hygrophilous grasslands and swamps that form the intricate vegetation landscape of Maputaland is of great scenic beauty and much of its biodiversity is of great interest to niche tourism such as botanists, birders, insect enthusiasts, and people in quest of elusive mammals. This niche market offers high economic returns for areas where big game tourism is less of an option (Schmidt-Soltau 2003; Kiss 2004; Vande Weghe 2004; Meadows 2006). This begs the question for the development of a network of reserves with tourism infrastructures designed for tourism options that suit the ecological criteria of the region. It appears regrettable to sacrifice the ecological quality of many ecosystems in the name of large game mass tourism. These areas exist and are already famous, the point of creating more appears hardly justified when most problems of these areas are yet to be solved (Vande Weghe 2004). Moreover, the costs of ecosystem management for tourism purposes should in future be compared to the income potential from using the ecosystem value for non-tourism purposes such as ecosystem services (Perrings and Lovett 1999), carbon sequestration and carbon release avoidance (Smith and Applegate 2004; Glenday 2006), and the recent willingness of developed countries and some philanthropists to pay for conservation instead of trying to make conservation pay for itself (Ellison 2003; Ellison and Daily 2003).

To conclude, the present study suggests the management of the Tembe elephant population and that of the greater Lubombo TFCA system once it is created by allowing fluctuations within the vegetation subsistence thresholds by the use of hunting and culling (preferably culling for ethical reasons when elephant family groups are targeted), for economic gain. It is also recommended that new forms of financial contributions enumerated above should be considered and integrated to complement or even replace traditional tourism revenues. It would be regrettable if social acceptability of such practices should dictate its non-use when no obviously viable alternative solution has been presented. It is also suggested that management goals should be aimed at an overarching degree of biodiversity conservation for regional and highly endemic ecosystem preservation and not just a single species of doubtful conservation status.

Conservation in a human-dominated rural landscape

The present study was able to quantify the level of utilisation of the vegetation in the rural community of Manqakulane. This community differs from other communities studied before in the Tembe region because of its location, which is further away from the main paved road from Ingwavuma to KwaNgwanase. Most other communities previously evaluated were situated along that road (Browning 2000; Brookes 2004; Tarr *et al.* 2004; Botes *et al.* 2006; Guldemond and Van Aarde In Press) and most likely demonstrated the effects of development through the access road to Maputaland until late 2002. This road was then supplanted by a newly built access road from the south, from Hluhluwe to Phelindaba and onwards to KwaNgwanase. Besides the geographical distance from a main road, the most notable difference for this rural community lies in the relative stability of its population base since 1996 (Peteers 2005).

Despite this relatively stable population base, the community is nevertheless undergoing a visible modernisation through the increase in number of households, reduction of number of occupants per household and a slight increase in the utilisation of modern materials for household construction (Gaugris 2004; Peteers 2005; Gaugris *et al.* 2007). In this modernisation process a high utilisation of natural resources is evident. The most promising and noteworthy trait of this community is demonstrated by the presence of Tshanini, a dream born in 1992, established in 2000 (Els and Matthews 2001), and gazetted in 2005. The example set by the Manqakulane people is now drawing attention from their neighbours, especially since their old dream has become a fenced-off area with official recognition. Two important aspects need to be considered to make Tshanini a success, ecologically, financially and for the benefit of Maputaland conservation. However, an underlying assumption needs to be presented before developing these aspects. Any development of the nature described below will need the security and safety offered by good governance at the country, provincial and regional level (Christensen 2004a), but also the help offered by children and adult education as well as health and sanitation infrastructure development (Schmidt-Soltau 2003).

The first aspect is to ensure that people in the community derive a financial benefit from the sacrifice of land demonstrated by the presence of Tshanini (Ellison 2003; Ellison and Daily 2003). This needs to be investigated in the way described for Tembe and the Lubombo TFCA. The site of Tshanini in itself has little attraction except for its scenic beauty and the lack of large and dangerous mammals that allow unworried wanderings through the forest. Geographically Tshanini is at a serious disadvantage from the direct competition of Tembe in terms of tourism, but also in that it does not offer a different landscape. Moreover, Tshanini is small, the access road to the site is difficult for most vehicles, and Tshanini does not have any infrastructure for receiving overnight tourists unless they are fully self-sufficient. It is therefore rather sad, albeit realistic, to state that Tshanini, although a conservation success story demonstrating the willingness of rural communities to participate in conservation, is unlikely to offset the costs of standard tourism infrastructure development in its current form (Kiss 2004), and it remains doubtful that should such an infrastructure be developed it would become profitable, as such ventures typically need 10 – 15 years and up to 30 years, to effect viable returns when they are successful (Perrings and Lovett 1999; Schmidt-Soltau 2003; Kiss 2004). In that respect, financial benefits must be returned to local people through innovative conservation systems, and as pointed out in some cases, ecotourism has sometimes less returns and conservation value than pure conservation (Kiss 2004).

Because Tshanini is a reality, it is important to demonstrate further that profits can be obtained so that other rural communities are drawn to the process (Kiss 2004). The most obvious route lies in exploring the potential for securing payments for conservation (Ellison 2003) and possibly entering the carbon trade in the form of credits for not releasing carbon (Smith and Applegate 2004; Glenday 2006). Another, older but demonstrated route would be the use of Tshanini as a hunting area for the region's wildlife. Ideally Tshanini should first be enlarged to ensure the fair chase ethics are respected (Chardonnet 1992), but the combination of conservation payments and carbon trade may trigger sufficient interest for other rural communities to join in the process and envisage the enlargement of Tshanini. In the hunting context, it would be necessary to effect small scale translocations from Tembe to Tshanini. As such the inclusion of one or several elephants for a period of a few months should be investigated to ensure that ecological processes of Tshanini forests and woodlands are maintained.

The second aspect, to be developed at the same time represents the development of a modern agricultural landscape based on organic farming (van Mansvelt *et al.* 1998) and sustainable and indigenous agro-forestry principles (Sanchez and Leakey 1997; Matson and Vitousek 2006). This aspect will be developed through securing soil fertility, intensifying and diversifying land-use, and enabling policies to facilitate land tenure, access to credit, infrastructure development, research, marketing and access to markets (Sanchez and Leakey 1997). The present study recommends the approach of an agro–forestry landscape because it has recently been demonstrated that it increases the quality of life and allows better overall conservation results in the development context (Berger *et al.* 2003). Additionally, it is considered a good human governed landscape to limit the effects of fragmentation and can maintain the biodiversity of a region by serving as a corridor landscape between wild systems (Kursten 2000; Nyhus and Tilson 2004; Wagner *et al.* 2006).

In conclusion, the present study suggests motivating other rural communities to follow the example set by the Manqakulane people, and the creation of a larger community-based conservation area should be envisaged, but with a different conservation target than Tembe. The development of such areas must coincide with the upliftment of rural populations and an amelioration of the overall quality of life starting with assured food security while keeping an enjoyable landscape to live in.

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