# Chapter 6
# Fencing for Purpose: A Case Study of Elephants in South Africa

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## Introduction

Conservation management requires planning and then implementation in order to effectively achieve objectives. Historically, major interventions were undertaken without a complete understanding (or regard) of the potential consequences, for example, fencing the western border of the Kruger National Park (KNP) negatively affects herbivore populations (Whyte 1985 cited in Grant et al. 2008; Grant et al. 2008; see also Loarie et al. 2009). Further, because the fences separated the animals from traditional water-sources (Grant et al. 2008), that intervention resulted in the necessity to create artificial water-holes, which in turn had unforeseen consequences (e.g. population decline of rare plains species – Harrington et al. 1999). Fencing for conservation management is a strong potential tool (Hayward and Kerley 2009), but we need to understand better our ability to nuance its implementation in order to maximise benefits while reducing costs.

Hayward and Kerley (2009) provide a comprehensive review of fencing and conservation, and highlight the complexity of creating and maintaining barriers in conservation land. South African conservation managers have been leaders in developing fencing as a conservation management tool (e.g. van Dyk 1997; Hayward et al. 2007; Grant et al. 2008; Gusset et al. 2008). One of the major reasons for fencing is to prevent human–wildlife conflict by preventing dangerous animals, such as megaherbivores or large carnivores, from entering human communities (Grant et al. 2008; Hayward and Kerley 2009).

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While there are clearly benefits from fencing, there are also a range of costs (Hayward and Kerley 2009). Fencing may be essential for a particular conservation objective or purpose, such as mitigating human–wildlife conflict (e.g. Grant et al. 2008; Hayward and Kerley 2009), but there are ways in which the associated costs can be reduced (e.g. through economies of scale, Lindsey et al. 2009). In this paper, I interrogate and explore some of the innovations in fencing for conservation which allow reduction of some of the costs associated with fencing, using African elephants (*Loxodonta africana*) in South Africa as a case study.

## Elephant Management with Fences in South Africa

The history of elephant management in South Africa was recently reviewed (Carruthers et al. 2008), and here I focus on the detail of reintroductions that occurred subsequent to 1980 (see Garai et al. 2004; Slotow et al. 2005), as this provides the main context for management through fencing. Naturally occurring populations of elephants occur at KNP, Addo Elephant National Park, Tembe Elephant Park (Carruthers et al. 2008), while elephants have been reintroduced to over 80 state-owned, communally owned and privately owned reserves (Garai et al. 2004; Carruthers et al. 2008).

There are many different types of fences that have been used for wildlife management, and a range of studies testing their effectiveness or appropriateness (e.g. Moseby and Read 2006; Vercauteren et al. 2006). Fencing has been used to specifically control the movement of elephants since the erection of the first "Armstrong" fence in Addo Elephant National Park which consisted of a strong, unelectrified barrier (Grant et al. 2008). Since 1980/1981, when elephants were introduced to Pilanesberg National Park (Anderson 1994), small reserves (exceptions were Ithala and iSimangaliso (see below)) in South Africa have been required to have an electrified complete perimeter fence of a minimum standard (see Grant et al. 2008 for fence information). The effectiveness of electric fences such as these, and other barriers in restricting elephants have been extensively studied (see Grant et al. 2008 for review).

The vast majority of reserves that have reintroduced elephants use fences 2.4 m high, and with either three or four live electric strands (Fig. 6.1). Having a fence capable of keeping elephants in does not mean that it is successful in keeping people out. Reserves have to patrol the border fence for two purposes, firstly reserve security against intruders, and secondly, to check whether the fence requires maintenance. A survey was conducted of all small reserves with elephants in 2001, and there was wide variation in how reserves dealt with these issues (Fig. 6.2). Guards in most state reserves were armed, whereas 40% of private reserves had unarmed guards, and about 40% of private reserves employed <5 guards (Fig. 6.2a). There was also variation in the frequency of fence patrolling, with almost all private reserves patrolling on a daily basis, i.e. a specific point on the fence was passed daily (Fig. 6.2b). Ten out of 57 (17.5%) reserves surveyed reported fence damage with no breakout, indicating that the fence does work despite elephants testing it, but

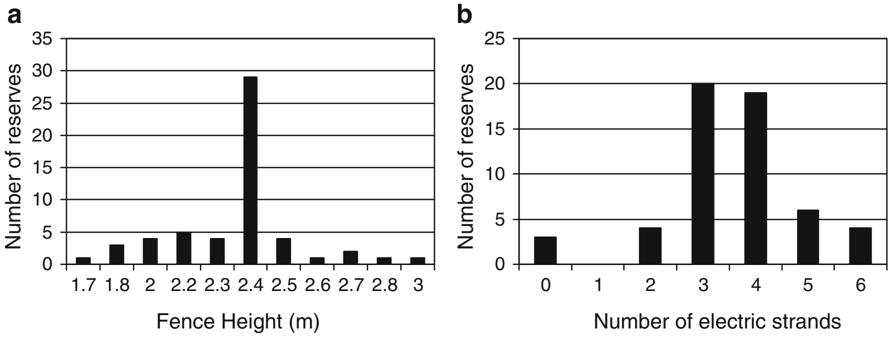


**Fig. 6.1** Fencing structure in reserves which introduced elephants. (**a**) Maximum height of fence (**b**) Number of live electric strands (most have an associated earth wire). Data are from a questionnaire survey of reserves conducted by the Elephant Owners and Managers Association by Dick Carr and collated and analysed by myself (see Slotow et al. 2005 for details of methods)

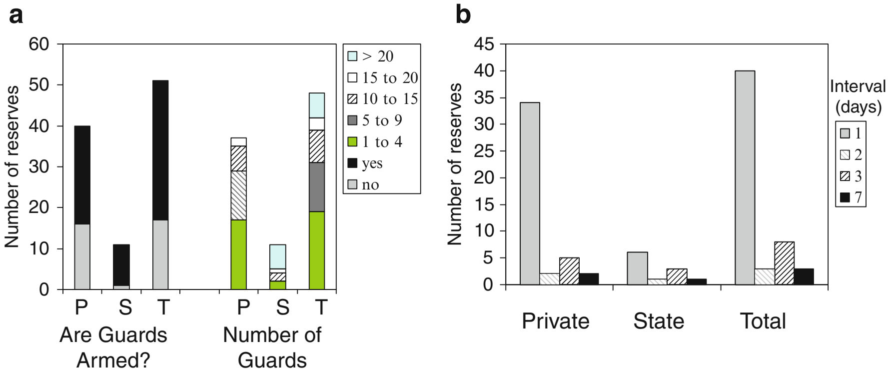


**Fig. 6.2** Security associated with fenced small reserves. (**a**) Security guards indicating if they are armed or not, and the number employed by the reserve. Legend reflects number of guards. *P*=Privately owned, *S*=State owned, *T*=Total regardless of ownership. (**b**) Frequency of patrolling of the border fenceline where numbers reflect the interval between patrols in days. Figure indicates whether the guards are armed or not, and secondly, the number of guards employed by the reserve. Data are from a questionnaire survey of reserves conducted by the Elephant Owners and Managers Association by Dick Carr and collated and analysed by myself (see Slotow et al. 2005 for details of methods)

emphasizes the need for continual patrolling to detect damage. However, breakouts do occur, with five out of 15 reserves that introduced older adult male elephants reporting breakouts (Garai and Carr 2001).

Large mammals are capable of learning about fences, and developing strategies to overcome the barrier. This is particularly true for electrified fences which become inoperative (Garai and Carr 2001). The process for introducing elephants into small reserves in South Africa includes a short period in a small (about 1 ha) holding facility (boma) (Garai and Carr 2001). The boma is electrified in the same manner as the boundary fence, and the elephants learn to associate fencing with electric shock, i.e. become fence-trained prior to release into the general reserve area (Garai and Carr 2001). This has, for the most part, proved successful, with relatively few breakouts from reserves over the years (but see read Garai and Carr 2004). Note that in the KNP, elephants are not fence-trained in this manner as they occur naturally in the area from the period before the reserve was fenced (Garai and Carr 2001), which may contribute to the relatively high number of breakouts from KNP (Grant et al. 2008).

## People and Electric Fences

A fence is only effective as a barrier if it is completely operational. Entry and egress require gates, and these have to be properly closed (Vercauteren et al. 2006), and if the fence is electrified, the integrity of the electrification of the gate needs to be maintained. Elephants have broken out of at least two reserves through gates (Garai and Carr 2001). In addition, the electrification of fences has to be maintained. At least five Foot and Mouth disease outbreaks adjacent to KNP have been attributed to buffalo (*Syncerus caffer*) escaping through fence breaks made by elephants (Grant et al. 2008). However, the reason why the fence-breaks occurred was poor quality of workmanship, and poor fence maintenance (Grant et al. 2008). In East Africa, effectiveness of fences was influenced by their location in relation to landscape factors as well as areas of high elephant densities, and maintenance (Kioko et al. 2008).

Garai and Carr (2001) assessed the success of introducing older male elephants into 15 different reserves, and identified the following aspects as factors leading to breakouts: "power failure on a perimeter fence during the rainy season; avoidance of the perimeter fence by swimming across a flooded river; destruction of fences in drainage lines caused by excessive rainfall; inability of management to patrol and maintain the perimeter fence during an excessively wet season; and lack of electrification of gates in the perimeter fence". Fence maintenance was clearly a major issue, despite the fact that many of these reserves regularly patrol their fences (Slotow personal observation).

There are a range of natural factors that can affect fencing, particularly electric fencing. Fences have to cross water-courses which flood in summer thunderstorms and deposit debris which shorts out the fence. A solution to this has been the use of sacrificial fences across drainage lines with continual problems, whereby a cheap, easily replaced section is constructed across the drainage line, and the whole section is simple replaced when compromised (personal observation). Large mammals pose a major problem in that carnivores use fences as hunting aids (van Dyk and Slotow 2003), often resulting in breakage or compromise of the electrics (personal observation). Unless quickly repaired, these can become weak-points through which elephants can break-out.

Fence maintenance is not only about natural factors, as the main problems with the KNP fence is theft and vandalism providing opportunity for animals to then break out (Grant et al. 2008).

In terms of damage to infrastructure within the reserve, managers have responded in three ways. Firstly, doing nothing, and absorbing the costs. This is particularly in cases where resources are not available, and as yet the costs have not escalated to the extent that intervention is deemed necessary. However, in most cases damage tends to escalate as repeat offences tend to build up into problem individuals (Slotow et al. 2008). In such cases, management has no option other than to remove the offending individual (who becomes known through repeat events (Slotow et al. 2008)). In most cases, these tend to be adult males (various managers personal communication; personal observation). The third management intervention is to fence out key infrastructure, which includes accommodation areas (camps), and water storage tanks of various forms (elephants damage tanks or break piping to get to water). Most often these are solar-powered, electrified fences which work effectively (if maintained).

## Unfenced Boundaries in Small Reserves

Unfenced boundaries are common in reserves outside of South Africa, and currently exist along international borders within Transfrontier parks. There are two reserves within South Africa that have elephants and that currently have unfenced boundaries, Ithala Game Reserve and iSimangaliso Wetland Park (iSWP, previously Greater St. Lucia Wetland Park). I will discuss each of these in turn as case studies. There have also been two occurrences where elephants moved out of reserves through gaps in the fence where large rivers exit reserves. Firstly, shortly after ten large male bulls were introduced from KNP to Hluhluwe-iMfolozi Park (HiP), one of these males moved out the reserve when crossing the Hluhluwe River. Apparently, he walked along the fence, entered the river, and then exited the river on the other side on the wrong side of the fence. He was captured and returned to HiP (Slotow unpublished data). In the second incident, two males moved out of Songimvelo Game Reserve in Mpumulanga, and into Malolotja Nature Reserve, Swaziland, by crossing the Komati River. These two animals remained in Malolotja, and thus pose a concern to managers there (Mtui and Owen-Smith 2006; Norman Owen Smith personal communication 2009).

Ithala Game Reserve introduced elephants between 1990 and 1993, young orphans from the KNP culls (see Slotow et al. 2005). The reserve is bordered in the north by the Phongola River, and that river frontage is not fenced. The land on the north of the river belongs to a number of communities and a small mining company. It is very sparsely populated, with little crop farming, and is mainly untransformed natural vegetation suitable for elephants. There is a steep ridge forming the northern edge of the river valley, which may prevent movement out of the valley bottom. More dense human habitation starts on top of that ridge. If any situation in South Africa was suitable for having an unfenced boundary, this would be it. As expected, elephants have started making excursions out of the reserve (the following is based on Ezemvelo KZN Wildlife (EKZNW) management reports collated by Taryn Gilson), with a brief movement out in 1992, the next by males in 1995, followed by the herd in 1998. In 1999, the whole herd moved out 3–4 times per year, and by 2003, they went out >10 times, staying out for up to 2 weeks. Since 2005, when satellite collars were fitted to the female groups, the furthest north that they have ventured is 2 km from the river. Excursions were mainly in the wet summer, when resources are more widely available. In general, the staff responded to excursions by chasing the animals back, either using a helicopter or on foot using load noises including gunshots. Three males were shot on return to the reserve in 2005 in a hope of discouraging future excursions (disturbance culling, see Grant et al. 2008), but this has been unsuccessful.

The river provides an important resource, so there will be fundamental problems with fencing the river out of the reserve as this will remove access to that resource, particularly for the endangered black rhinoceros (*Diceros bicornis*). In addition, the river has major aesthetic value for tourists, which will be compromised by a fence. Reserve management, therefore, faces a conundrum, and is currently working with the concept of virtual fences (see below).

iSimangaliso Wetland Park introduced elephants in 2001, and faces a problem in the southern part of the park around Lake St. Lucia itself. The land within the reserve does not completely surround the lake, which makes it possible for elephants to move into the lake, and then out onto land that is not contained by fencing. This land is either occupied by communities, or private land-owners practicing various land-uses. In addition, the eastern border of the lake is made up by the Indian Ocean, making it theoretically possible for elephants to walk around the fence on the beach. The lake is shallow enough for elephants to easily cross, and large areas dry out during drought years, meaning that the reserve has to erect temporary fencing along those areas when the lake dries up, and remove the fences when the lake floods. Shortly after introduction into the reserve, two young males walked north along the lake shore, and walked around the fence on the northern border of the lake (Slotow unpublished data). They had to be recaptured, and were returned to Hluhluwe-iMfolozi Park from which they were originally translocated from (Slotow unpublished data).

A further problem faced by iSWP is that two key reserve boundaries are made up of rivers. The northern and eastern border of Mkuze Game Reserve is along the Mkhuze River, which is accessed by the communities on the north/east banks for their own use, as well as for their livestock and agriculture. Historically, the river was not fenced, which led to people and their livestock moving freely into the reserve, and animals leaving the reserve. The proclamation of the Greater St. Lucia World Heritage Site, and the plan to introduce large carnivores, as well as a major raid by most of the elephants into an orchard on the east bank, led to a decision to fence that boundary. This resulted in the river being fenced out of the reserve, requiring innovative planning to provide artificial water for the animals. The second major water-source that was fenced out of the reserve was Nyalazi River, on the west bank of Lake St. Lucia. This river has a community living on the western shore, and is the most substantial and consistent fresh-water source in the region (the lake becomes hypersalinic during drought years), necessitating artificial provisioning of water. The ecological effects of fencing-out these rivers have not been studied. In Mapungupwe National Park, which has its own elephant population, SANParks have erected a fence along the Limpopo River border with the Tuli Block, primarily to prevent additional elephants moving into the reserve from the larger Tuli population. This fence reduces the aesthetic of the river frontage, and also prevents other animals from access to the river (Norman Owen Smith, personal communication).

## Enclosures vs. Exclosures

Fencing of elephants is generally considered to be a problem of enclosing them inside a reserve in order to prevent them escaping. However, fences are also important for excluding elephants from a specific area within the reserve, such as camps, staff housing, infrastructure or even key natural resources of high conservation value, including threatened plant species (reviewed in Grant et al. 2008). The purpose of the fence needs to be clearly understood, and an exclosure and enclosure may have very different purposes. For example, it may be desirable to preclude only elephants from entering a particular area, whereas all species may be prevented from leaving the reserve. Further, fences may also be established to prevent humans from entering a protected area. In addition to direct management benefits, exclosures also provide a key resource for scientific understanding of the effects of elephants on the ecosystem (Grant et al. 2008).

## Ecological Effects of Fences

Fences constrain the movement of elephant, and in a relatively small reserve, increasing elephant densities (Slotow et al. 2005; Mackey et al. 2006) may negatively affect ecological processes or biodiversity (see Grant et al. 2008 for review). We do need to separate the concern over elephant concentration into small areas on biodiversity (Kerley et al. 2008, but see Landman et al. 2008) from the effect of the fence as a barrier per se. Fences affect elephant movement, and in extensive areas may cause them to bunch up against the fence (Loarie et al. 2009). However, we have recently shown for Pilanesberg National Park, female elephant use the fence more for movement between foraging areas, presumably with low foraging impact near the fence, but that the edge effect of fencing may result in higher vegetation impacts deeper in the reserve (Vanak et al. 2010).

## Permeable Fences

Fencing may reduce gene flow from natural populations outside of protected areas and also has localised effects on biodiversity through focussing biotic processes (Hayward and Kerley 2009). If a fence needs to exist, then it should be as permeable as possible, preventing only movement of the target species. This would allow all non-target species to move freely, avoiding some of the negative consequences of fencing (see Hayward and Kerley 2009 for costs associated with fencing).

One of the first such fences in Africa was developed by Natal Parks Board (now EKZNW) to restrict the movement of rhinoceros. A singe strong cable was strung about 30 cm above the ground. This prevented rhinoceros from crossing the fence as they could not lift their legs over it. This allowed rhinoceros to be restricted into specific areas of a reserve, or to prevent them from moving onto a public road through a reserve and thus posing a threat to motorists (and vice versa) such as at Weenen Game Reserve, KwaZulu-Natal (personal observation).

This concept was applied by EKZNW to the conservation management of elephants at iSWP. In this case, an electrified strand was placed about 2 m above the ground with an associated earth strand. This prevented elephants that were introduced to the park from moving out into the surrounding community areas. This proved very effective in that no elephants broke-out of the reserve through this fence (Slotow unpublished data). The fence did allow other species to move freely, and has now been modified to a complete standard electrified fence to allow the introduction of a wider range of species (personal observation).

Besides this fence having the ecological advantage of allowing movement of other species, it is also much cheaper than a complete fence, and requires less maintenance as the electrics or fence itself are not broken by other species (van Dyk and Slotow 2003; Hayward et al. 2007).

The concept of single electric-strand fencing to control the movement of elephants has become more widely applied, for example some areas within the Associated Private Nature Reserves (APNR) adjacent to KNP use such fencing to exclude elephants from camps (personal observation), and Phinda Private Game Reserve (Lagendijk et al. 2011) and Tembe Elephant Park have used it to exclude elephants from key threatened Sand Forest areas. Managers are learning through experience to modify the fences to be more effective. For example, in the APNR, for the single electric strand exclusion fence, the electric wire is led down the support poles to prevent the elephants from pulling out the poles, and thereby shorting the fence (Slotow personal observation). At Phinda, the height of the single electric strand has been lowered slightly to prevent young elephants moving under the fence (whereupon the mothers become agitated and break through the fence (Tarynne Dickerson, pers. comm.)).

## Virtual Fences

Modern technology provides the opportunity to view fencing from another perspective. In the context of elephants, fencing is either to protect people from risk, or to prevent elephants from entering a particular area for an extended time. A large portion of the risk associated with elephants, i.e. when people and elephants come into contact, is the surprise factor, both in terms of location and timing (Slotow unpublished data). If we look a the Ithala example above, the elephants are not spending a lot of time out of the reserve, and even when outside the reserve, they are not necessarily entering areas of high human activity. It is relatively unlikely that they will encounter people, i.e. it is a low-risk situation. However, there may be times or circumstances when the risk of an incident escalates greatly. In that case, managers would need to intervene, which may simply mean warning, for example, the staff of the mine across the river. GPS collars can provide real-time data on elephant locations. The management of Ithala have set up a process, whereby each of the elephant herds is collared with a GPS collar, and they have identified "hot-spots" of risk outside the reserve. As soon as the elephants enter a buffer area around those hot-spots, the management of the staff respond in some way. This means that they can potentially effectively manage the risk without incurring the huge ecological and financial costs of fencing-off the river.

iSimangaliso Wetland Park has a different situation, in that there are two elements of risk, of the elephants leaving the reserve, but also of risks of human–elephant conflict within the reserve. Since iSWP has excellent GSM cell-phone coverage, it is possible to use real-time feedbacks on their location relative to specific parts of the landscape. Computer technology (www.yrless.co.za) allows an ARCVIEW shape-file containing the border of the reserve to be loaded, and any time the elephant collar moves across that border, a notification is immediately sent to pre-specified cell-phone numbers giving the location of the elephant, the time and a local geographic reference point.

Within iSWP itself, there are two kinds of risk, firstly to staff and visitors within the camps which are not fenced. Secondly, to contractors who are working on the reserve, for example in harvesting from forestry plantations within the reserve. The same principle is applied in these instances, were each camp has a virtual border loaded into the computer system, and each time an elephant enters or leaves that zone an SMS is sent to the pre-determined staff member, for example the camp manager. The camp manager can then make an appraisal of the situation, and whether any intervention is necessary, such as moving people to safety. In terms of the forestry workers, the zone can be moved around, i.e. the shape-file updated when they move into a new block, and the foreman can be notified of any elephants within the zone. In the same way as Ithala above is managing the risk, iSWP has a mechanism whereby it can manage the risk of human-elephant conflict using virtual fences.

Some of the problems that have been encountered with the system are that (1) The border needs to be moved outside the actual border by about 100 m to allow for GPS error, which otherwise gives false alarms when elephants walk alongside the fence. (2) SMS numbers for alerts need to be updated when there is staff turnover, otherwise the correct staff member is not notified. (3) Contractors do not really use the system as they do not see the elephants much, i.e. they do not associate a major risk with elephants.

## Discussion

Fencing of reserves was primarily aimed at preventing elephants from leaving reserves into the surrounding communities and farmland. Despite the breakouts mentioned above, fences have been largely effective at preventing human–elephant conflict outside reserves (Slotow et al. 2008; Twine and Magome 2008), other than the Greater KNP complex (which includes the adjacent private reserves) (Grant et al. 2008). For managers of smaller reserves, the main concern tends to be human–elephant conflict within the reserve, with 72% of human fatalities by elephants between 2002 and 2007 occurring within protected areas (Twine and Magome 2008), including aggression towards people and other species, and damage to infrastructure (Slotow et al. 2008). Although it is possible to fence out accommodation areas, all fatal interactions have occurred in the general veld (Slotow unpublished data), making such conflict impossible to manage through conventional fencing. More widespread use of virtual fences may be an alternative worth pursuing.

Fencing for ecological exclosures in order to remove the effect of elephants has been relatively successful (Addo: Lombard et al. 2001; Phinda: Lagendijk et al. 2011). Such exclosures, and those erected for scientific study can also produce useful insights into the ecological effects of elephants (Grant et al. 2008).

Badly aligned fences can have major consequences for biodiversity, for example by interrupting key movement patterns (Hayward and Kerley 2009), or when elephant bunch up against them in the wet season (Loarie et al. 2009). This can result in major mortality of key species, or indirectly by shifting the ecological influence of biotic factors such as grazing or browsing (see examples in Hayward and Kerley 2009). The key issue of fencing out of rivers, and the ecological and aesthetic consequences of this, needs study.

Hayward and Kerley (2009) coin the phrase “metaphorical” fences to describe alternative approaches to barriers such as using *Capsicum* repellents (Osborn and Rasmussen 1995). Other alternatives being tested also include the use of bee (*Apis mellifera*) hives (King et al. 2009), or even the sound of agitated bees (King et al. 2007; see also Grant et al. for discussion of alternatives to fencing). An important result to emerge from this overview is the potential for permeable fencing which achieves a specific purpose, but reduces both the financial and ecological costs. It is important that proper studies be undertaken to refine different methods (e.g. Moseby and Read 2006) for permeability. It is clear that permeable fences are not relevant only for controlling larger species, for example in Australia it is the smaller species such as feral cat (*Felis catus*) that need to be constrained, with larger species such as kangaroos being able to jump over the fences; sophisticated designs could facilitate this (see Moseby and Read 2006). I take the conceptualisation of alternative methods a step further, explaining the use of virtual fences using remote-sensing technology as alternatives both within reserves to avoid fencing camps, or outside reserves to avoid fencing perimeters. The uses of such alternatives need to be better understood and tested.

Fences are not infallible, particularly given the maintenance necessary for electrification (particularly when human vandalism and theft are rising), and the sophisticated ability of elephants to learn how to overcome fences (Grant et al. 2008). The key issue for using fences to contain elephants is not necessarily the absolute strength of the fence, but rather the integrity of the electrical system. It may be possible to reduce vandalism and theft, through working with the community, and to reduce human shorting of the fence for transit, for example by illegal immigrants through KNP, by placing a second permeable electric fence just within the boundary fence, which will allow people to move freely under it while maintaining a barrier to elephants. To improve consistency, remote sensing technology could be placed at key points on the boundary to alert managers when power goes down, at sacrificial river-crossings, for instance, especially in reserves that do not patrol the fenceline daily.

Gates are weak points, and some form of barrier that does not require human intervention at points of entry/egress is ideal (see Vercauteren et al. 2006 for some examples), and electrified grids across the road work to contain African wildlife, including elephants (personal observation at a range of reserves). Fencing major water-bodies is difficult, and similar problems to those indicated for elephant are evident in electrified road-side fences used to control moose (*Alces alces*), where moose enter the road area through gaps in the fence-line such as at lakes (Leblond et al. 2007). Fences in such situations require management flexibility, for example erection of temporary fences that can be removed when flooding occurs, or localised use of repellents (e.g. *Capsicum*, Osborn and Rasmussen 1995). Virtual fences may also prove useful in these situations.

There was a lot of variation among reserves as to the effort invested in patrolling for maintenance and security, which is a high, ongoing cost to fencing. While effort could relate to the local circumstances, it may prove valuable to develop effective and "best practice" in the industry through sharing information among stakeholders.

Private land owners tend to be strongly independent, but there is value in combining together to form larger conservancies (Lindsey et al. 2009). In such conservancies, the internal fences between properties are removed, and all members contribute to the perimeter fence of the overall conservancy. This leads to economies of scale regarding fencing (see Lindsey et al. 2009) as the overall distance of fence relative to the area of land declines with increasing size (Vercauteren et al. 2006). In addition, maintenance cost per individual owner would decline in a conservancy through economies of scale (a single patrolling programme rather than each separate farmer having their own patrolling programme). Finally, within a conservancy, the number of corners within the fenceline and river-crossings decline, resulting in a reduction in weak-points and expense: corners and end points contribute >80% of the material costs of fences (Vercauteren et al. 2006). Importantly, cadastral boundaries are often formed by rivers, which are key ecological resources, and joining land parcels will result in the inclusion of rivers within the fenced area. There are obviously ecological and economic incentives for forming conservancies (see Lindsey et al. 2009), and from a fencing perspective, it makes sense for land-owners to join together in conservancies.

While fencing to prevent human–elephant conflict has become required in South Africa (DEAT 2008), it is not widely used elsewhere, and other Governments are going to need to consider fencing along hard boundaries where transformed human community land borders natural areas, such as along the western border of Serengeti National Park, Tanzania. Governments have tended to be slow to react to changing scenarios that potentially require fencing (Hayward and Kerley 2009), but the private sector is initiating fencing of some reserves in East Africa (Kioko et al. 2008).

Hayward and Kerley (2009) conclude that the costs of fencing far outweigh the benefits, but their approach was simply a listing of benefits next to costs. The issues that they list in their Table 2 should not be equally weighted, and I believe that, depending on the circumstances, the benefits far outweigh the costs. For example, private game reserves in South Africa would not be allowed to introduce key tourism species if they do not upgrade their boundary fence to a minimum regulated requirement for particular species such as elephant (DEAT 2008). If they did not fence, then these reserves would not exist, and the benefits that they have brought to conservation (e.g. Gusset et al. 2008, but see Hunter et al. 2007; Slotow and Hunter 2009) would not persist. Hayward and Kerley (2009) conclude that fencing to mitigate Human–wildlife conflict is likely to persist, and in this chapter, I have demonstrated how careful planning can mitigate some of the costs (including ecological) while still achieving conservation objectives. Importantly, the costs associated with fencing can be reduced through economies of scale with increasing area, and consolidation of land-parcels through conservancies (e.g. Lindsey et al. 2009) and other partnerships such as Transfrontier parks (van Aarde and Jackson 2007). The key purpose of a fence needs to be defined, so that the most effective solution, permeability, can be implemented.

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