Chapter 2
Perspectives on Fencing for Conservation Based on Four Case Studies: Marsupial Conservation in Australian Forests; Bushmeat Hunting in South Africa; Large Predator Reintroduction in South Africa; and Large Mammal Conservation in Poland

Matthew W. Hayward

Introduction

Effective conservation requires the separation of biodiversity from processes that threaten it (Hayward and Kerley 2009). Barrier fencing is one method that conservation managers can employ; however, more “metaphorical” barriers can also perform a similar function (Hayward and Kerley 2009). Fences also provide a defined management unit which minimises confusion about the destination of conservation actions aimed at stopping threats as diverse as intruders, poachers, land clearance, introduced predators, disease and weeds (Hayward and Kerley 2009).

The fundamental benefit of conservation fencing is that it separates biodiversity from threats to its existence and, hence, is critical to conservation actions, yet fencing for conservation also has some clear costs (Hayward and Kerley 2009). Fences have a high financial cost, as well as ecological costs such as inhibiting movement patterns, isolation, inbreeding, predation sinks, continuing management, visual costs and ethical issues (Hayward and Kerley 2009).

This chapter investigates some of the key benefits and problems of employing fencing for conservation purposes. These costs and benefits of fencing are discussed in light of four case studies from three countries in three continents. The first case study highlights how using poison, instead of a physical fence, as a barrier to

M.W. Hayward (✉)
Scotia Sanctuary, Australian Wildlife Conservancy, CARE P.O, Wentworth, NSW 2648, Australia

Centre for African Conservation Ecology, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Mammal Research Institute, Polish Academy of Science, Białowieża, Poland

School of Biological, Earth and Environmental Science, University of New South Wales, Sydney, Australia
e-mail: hayers111@gmail.com

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introduced predators may not be a successful long-term strategy for conserving the vulnerable macropodid marsupial, the quokka *Setonix brachyurus*. The second case study of bushmeat hunting in the Transkei region of South Africa illustrates how critical fence maintenance is to ensuring the effectiveness of fences for conservation. The third case study illustrates how effective fence maintenance has ensured the success of large predator reintroductions in South Africa's Addo Elephant National Park; however, this in turn has created management problems through population isolation. Finally, I look at how human influences around Poland's Białowieża Primeval Forest effectively act as a barrier fence to restrict animal movements.

Case Study 1 – Metaphorical Fences of Poison: Conserving the Quokka in Australia's Northern Jarrah Forest

The quokka is a 3–5-kg macropodid marsupial that is endemic to the south-western corner of Western Australia (Kitchener 1995). The species is one of the most abundant in the fossil-bearing sites of the region (Glauert 1948; Cook 1960), where its fossils peaked in abundance around 20,000 years ago (Balme et al. 1978). Aboriginal people regularly hunted them by burning their swampy habitats and spearing them as they fled the fire (Gardner 1957; Gould 1973; Nicholson 1981). Quokkas were also abundant when Europeans arrived in the region, such that they were classed as "vermin" by forestry officials (Stewart 1936). Reports of the quokkas' decline on the mainland in the 1930s are common in the literature (White 1952; Serventy et al. 1954; Barker et al. 1957). Conversely, the two island populations – Bald and Rottnest – remained stable through this period (Waring 1959; Storr 1965). Although the 1930s saw the major decline of the quokka, recent research suggests this decline has continued (Hayward et al. 2003) (Fig. 2.1).

Numerous factors were listed as causing the initial decline of the quokka, including disease, urbanisation, habitat alteration, competition with introduced herbivores and predation (White 1952; Main 1959; Short and Calaby 2001). Of these, there is only evidence for predation and habitat alteration playing distinguishable roles (Hayward et al. 2005a). There are several lines of evidence implicating the European red fox *Vulpes vulpes* in the quokkas' decline. Critically, the decline of the quokka on the mainland corresponded to the arrival of the fox in the south-west (King and Smith 1985); quokka populations on fox-free islands have remained stable; reintroduced quokka populations have failed due to predation by foxes (Short et al. 1992) and the fox remains the major mortality source today (Hayward et al. 2005a). Predation by feral cats *Felis catus* seems unlikely to be the cause of the quokkas decline as they coexist on Rottnest Island without any apparent population limitation (Main et al. 1959). It seems likely that the quokka is within the preferred weight range of prey of the red fox, but larger than the preferred prey weight range of cats (Hayward et al. 2006). There is no evidence of an increase in predation by native carnivores or of humans in the 1930s (Hayward 2002; Hayward et al. 2005a). Finally, reanalysis of the evidence for disease suggests that it was more likely surplus killing by newly invading red foxes (Short et al. 2002).

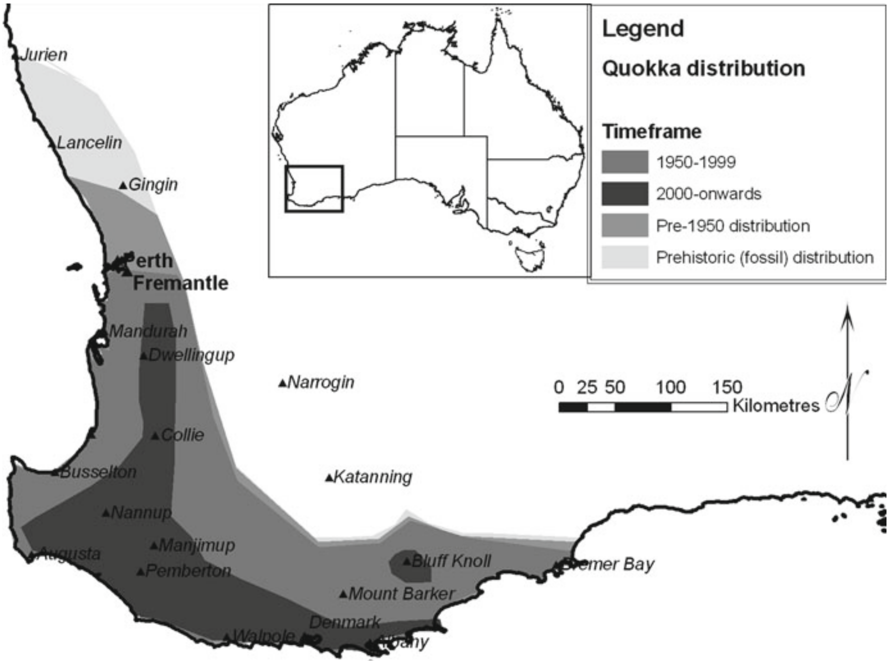

Fig. 2.1 Map showing the decline of the quokka from Hayward (2002). The area of quokka occupancy prehistorically is shown as the *dotted region*, prior to 1950 is hatched, from 1950 until 1990 is *light grey* and in 2000 is shown as *dark grey*

The quokkas' decline may also have been driven by habitat alteration. The Swan Coastal Plain has been largely cleared of natural vegetation for urban development and so few quokka populations remain there (de Tores et al. 2007). The fragments that do remain are small and susceptible to invasion by foxes (Hayward 2002). The jarrah forest is a multi-use area that includes forestry, bauxite mining, water storage (dams) and conservation. Forestry has not affected quokkas substantially as the 20 m buffer zone around quokka swamps appears sufficient to protect them (Calver and Dell 1998a, b; Hayward 2002). The large-scale clearance involved in mining has affected individual quokka swamps; however, this is a modern impact and mitigation measures are now put in place to protect native fauna, including quokkas (Hayward 2002). Quokka swamps have also been dammed to provide water, but again this has only affected a few individual populations since the 1930s (Hayward 2002). The biggest habitat alteration quokkas have faced is due to change in fire regimes. Quokkas evolved to cope with Aboriginal burning regimes of fires every 3–4 years in the jarrah forest that entered the swamps every 6–8 years (Wallace 1966; Burrows et al. 1995; Ward and Sneeuwjagt 1999). They then had to cope with complete fire exclusion during the early European occupation and more recently to low intensity, prescribed burns on a 7-year rotation (Hayward et al. 2005b). Fire can eradicate individual populations; however, quokkas recolonise swamps within months of a fire, reach peak densities at 8–15 years, before becoming absent in long-unburnt swamps (Christensen and Kimber 1975; Hayward et al. 2005b, 2007e). This pattern occurs because the major quokka food plants resprout rapidly after fire and they attain peak abundance within reach of foraging quokkas at 8–15 years (Hayward 2005; Hayward et al. 2005b). After this, the dominant canopy plant species of quokka swamps, *Taxandria linearifolia*, blocks out most of the light reaching the ground, leading to an opening of the shrub and herb layer and reducing the available refuge from predation (Hayward et al. 2005b; Hayward 2008).

Interestingly, an increase in fires since permanent settlement on Rottnest Island led to vegetation changes from woodland to heath (Pen and Green 1983), particularly in the presence of quokka overgrazing (Storr 1963), yet this has not affected quokka abundance (Johnson et al. 1989). Hence, it seems that the quokka is resilient to habitat alteration in the absence of red foxes; however, it requires the refuge offered by patches of long-unburnt swamp interspersed with recently burnt areas to provide food in the presence of foxes (Hayward 2002, 2005; Hayward et al. 2005b). Thus, the quokka may not be restricted to such habitat specificity on the mainland because these areas are most favourable to it; rather, they may be the habitat least "favoured" by the agent of the quokka's decline – the red fox. In essence, these may be refuge habitats.

Conservation managers are charged with a difficult task, particularly in multi-use forest areas (Hayward 2009a). Western Australia's native fauna has a high tolerance to the poison Sodium monofluoroacetate, which is the active constituent of 1080 ® (see summary by de Tores and Marlow 2012). Hence, managers tasked with conserving quokkas implemented a monthly poisoning campaign around known quokka swamps as part of the Western Shield programme (de Tores et al. 2004). After 6 years of fox poisoning, however, there was no evidence of a population response by quokkas, although two unbaited populations went extinct in that time (Hayward et al. 2003, 2005a). It was concluded that quokkas originally existed as a metapopulation that has collapsed since the arrival of the fox in the 1930s (Hayward et al. 2003), despite current movement patterns being sufficient to allow colonisation of adjacent, suitable patches (Hayward et al. 2004). Future management will include small-scale, precise burns of quokka swamps to create a mosaic of time-since-burn age classes (Hayward et al. 2005b, 2007e).

The plight of the quokka illustrates that "metaphorical" fences of poison are available and can potentially perform the same function as physical structures (see also de Tores and Marlow 2012). The continued vulnerability and decline of the quokka suggests that relying solely on poisoning may not be a long-term solution, particularly given the likelihood of foxes developing aversion or even tolerance to 1080 as rabbits *Oryctolagus cuniculus* have done in less than 100 years (Twigg et al. 2002).

This has severe ramifications for conservation management throughout Australia and New Zealand, where poison is frequently used to reduce the densities of introduced species. While physical fencing may be an extremely expensive option (Hayward and Kerley 2009), eventually the high construction costs will be allayed compared to the continued costs of poisoning, particularly if poisons become less effective (Fig. 2.2).

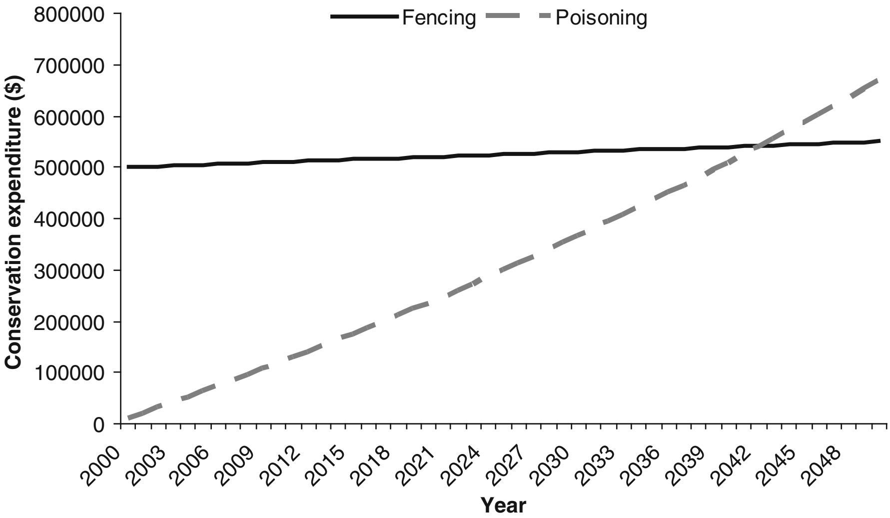

Fig. 2.2 Schematic representation of how continued annual poisoning will eventually cost more than the construction and maintenance of a physical fence. The hypothetical fence cost $500,000 to build, but only $1000 per annum for maintenance. The hypothetical poisoning campaign costs $10,000 per annum, but loses effectiveness by 1% per year as animals develop bait aversion and tolerance to the poison

Case Study 2 – Ineffective Fencing: Bushmeat Hunting in the Dwesa and Cwebe Nature Reserves, South Africa

Dwesa and Cwebe Nature Reserves are on the Wild Coast of South Africa's Transkei region between Port Elizabeth and Durban. This area has received relatively little attention from ecologists until recent years (Hayward et al. 2005c). The combined area of the reserves is 15,254 ha and they are covered by similar coastal indigenous rainforest communities, but are separated by the Mbashe River (Timmermans and Naicker 2002). Like all conservation areas in South Africa that house large and potentially dangerous wildlife species, Dwesa and Cwebe were fenced originally; however, this fencing has fallen into disrepair in recent years (Hayward 2009b).

It may be argued that there are two phases to the conservation of Dwesa and Cwebe. Following the creation of the reserves, several species were reintroduced including "plains game", such as white rhinoceros *Ceratotherium simum*, blue wildebeest *Connochaetes taurinus* and plains zebra *Equus quagga*, which did not originally occur in the region (Skead 1987; Feely 1999; Hayward et al. 2005c). These species did well on the grasslands that grew following clearing of some parts of the coastal forests, and they were frequently observed by tourists.

More recently, the fence has fallen into disrepair and has even been removed in places, which has led to a high level of human encroachment and poaching throughout both reserves (Hayward 2009b). This has resulted in the "plains game" altering their habitat use by spending much of their time inside forests to avoid encountering poachers (Hayward 2009b). Even bulk grazers, like the white rhinoceros, appear to spend much of their time in forested areas rather than on the grasslands. There have been observations and reports of poaching events on all the large game species (Hayward 2009b).

Clearly, over-harvesting by humans is the biggest threat to the larger fauna of Dwesa and Cwebe. Fencing was originally constructed to minimise this threat (and, conversely, the threat of large wildlife to humans). Lack of investment in fence infrastructure by way of maintenance has led to high levels of bushmeat hunting (Hayward 2009b). Both Dwesa and Cwebe have rangers who regularly go out on anti-poaching patrols (Hayward 2009b); however, their job is much more difficult in the absence of a clearly defined management unit to reiterate to potential poachers that they are entering conservation land and a barrier fence to impede their progress in or, more likely, out while carrying butchered meat and trophies. Poachers effectively reduce the size of conservation areas (Hilborn et al. 2006), and the small size of Dwesa and Cwebe means there is little scope for the fauna to utilise poaching refuges (areas too far from villages or in too dense habitat to make poaching an optimal strategy)(Wilkie and Carpenter 1999). Thus, for fencing to be an effective conservation action, it must be adequately maintained, and this requires adequate investment in the conservation body tasked with managing the area and, ideally, the local community to allow them to reap the financial rewards of living alongside a conservation area, which may reduce the amount of damage the fence receives.

Case Study 3 – Effective Fencing: The Reintroduction of Top-Order Predators to South Africa's Addo Elephant National Park

South Africa's Eastern Cape Province has experienced a rapid transition from marginally viable pastoral land use to both public and private conservation which yields 4 times the profit while employing 4 times as many people (Kerley and Boshoff 1997; Sims-Castley et al. 2004). As part of this process, large numbers of wildlife have been reintroduced to the province, including large predators (Hayward et al. 2007a–c).

The managers of Addo Elephant National Park reintroduced lions *Panthera leo*, leopards *P. pardus* and spotted hyaenas *Crocuta crocuta* in 2003 and 2004 (Hayward et al. 2007d). Although South African National Parks managers manipulated the sex ratio of the founder population to slow the potential population increase, the populations of lions and hyaenas increased rapidly. This is a feature of the reintroductions of lions and hyaenas to the 12 reserves in the Eastern Cape, such that overpopulation is now a major problem (Hayward et al. 2007b, d).

The success of large predator reintroductions in the Eastern Cape is largely attributable to fencing. Large predators were driven extinct in the region in the late nineteenth century by human persecution (Skead 1987). Large predators invariably come into conflict with humans and in most developed societies are increasingly restricted to isolated conservation areas (Bauer and van der Merwe 2004; Bauer et al. 2004). Encroachment and poaching act to further limit the area available to these species. Effective fencing greatly minimises human-animal conflict, which ensures large predators are free from retributive human persecution. Effective fencing also minimises encroachment and poaching. Hence, it is clear that the fencing around Addo Elephant National Park, and other reserves in the Eastern Cape, is effectively assisting in conserving large predators. The Eastern Cape reserves are not alone in linking their reintroduction successes with the presence of fencing. The reintroduction of African wild dogs *Lycaon pictus* has been attributed to the presence of fencing also (Gusset et al. 2008).

Fencing does raise some potential problems. Firstly, each population is isolated and there is no potential for natural mixing of populations to avert inbreeding, which has been identified as a problem about to arise (Frankham 2009). There is the potential, in the Eastern Cape, to bring down fences between adjacent reserves to create a mega-conservancy (Hayward et al. 2007b). If this does not occur, or where it is impossible, then continued management of animals will be required to avoid loss of genetic diversity.

A second potential problem is the effect of fencing on the spatial and social behaviour of the reintroduced species. Large predator home range sizes are generally negatively related to the biomass of preferred prey (Nilsen and Linnell 2006; Hayward et al. 2008). Thus, their territory size can be predicted using the biomass of preferred prey. Data from Addo Elephant National Park show that the range size of lions and spotted hyaenas (and a leopard) are not constrained by the fences and conform to predictions based on the availability of preferred prey (Hayward et al. 2008).

There were two male coalitions in Addo's lion population that initially battled for social dominance of the park's lionesses. After several months, one coalition became dominant and this forced the subordinate males to spend much of their time on the periphery of the dominant coalition's territory – that is, along the fence line (Hayward and Hayward 2007). Is the fence line limiting their movements? Their home range size is still as expected, based on the availability of food. In unfenced populations, subordinate lions (or nomads) are forced to live on the periphery of pride territories (Schaller 1972). Hence, if Addo's lions were surrounded by other prides rather than fences, subordinate or nomadic lions would be forced to live along the periphery of these territories and, thus, it seems unlikely that the fences are substantially affecting lion social behaviour.

The barrier fencing around Addo was financially costly, although this cost is likely to be rapidly recouped with the increase in tourism attributable to the reintroduction of large predators (Hayward et al. 2007b). While isolation is a factor that requires ongoing management and reduces the value of fenced reserves for conservation (Hunter et al. 2007), the return of species to the region for the first time in over 100 years seems to be a conservation advance for the species through distribution expansion, increased abundance and spreading risk to more populations.

Case Study 4 – Fence-Free Barriers: The Fauna of Białowieża Primeval Forest, Poland

Białowieża Primeval Forest is a remnant of the once, great temperate deciduous forests that covered much of Europe (Jędrzejewska and Jędrzejewski 1998). The forest spans the Polish and Belarussian border, but is largely isolated by a border fence (to the east) and cleared agricultural lands and urban areas to the north, south and west. The effect of the border fence is discussed elsewhere in this book (see Kowalczyk et al. 2012). Here, I discuss my impression of the "metaphorical" fence that limits animal movements and distribution to the north, south and west of the forest.

Figures illustrating the locations of radio tagged wolves *Canis lupus*, Eurasian lynx *Lynx lynx* and European bison *Bison bonasus* provide graphic evidence of the effectiveness of the "metaphorical" fence to the north, south and west of Białowieża (see Figs. 13.1–13.3 of Kowalczyk et al. 2012). There are almost no locations of any of these species outside the forest. Animals leaving the forest not only face the threat of accidental mortality from vehicle road kills, but also face human persecution (legal or illegal – see Kowalczyk et al. 2012) and harassment from dogs.

The fauna of Białowieża has faced several 100 years of selection at the hands of humans (Samojlik and Jędrzejewska 2005). Białowieża's forest survived largely because it served as a hunting ground to Polish kings and Lithuanian dukes. Managers were employed to protect the forest and ensure the king's wildlife was not poached. Areas outside the king's forest were cleared. Since the seventeenth century, humans have been killing animals that left the forest, while protecting those that remained inside (until the rare periods that the king chose to hunt) (Samojlik and Jędrzejewska 2005). This unnatural selection must have shaped the behavioural ecology of these species and probably explains the sedentary behaviour and forest preferences of the European bison (compared to its North American cousin).

Thus, even in the absence of physical barrier fencing, metaphorical barriers can have dramatic impacts on the ecology of wildlife. Management efforts are now focused on resurrecting movement corridors to increase connectivity to adjacent habitat patches.

Conclusion

The case studies discussed above illustrated a diverse range of benefits and costs of conservation fencing. A cost-benefit analysis may determine which of these were valuable tools in the conservation arsenal at these sites.

Would the Quokka Survive on Mainland Australia Without the Metaphorical Barrier of Poison?

Quokkas have persisted on the Australian mainland in sympatry with red foxes for over 70 years. The recent introduction of fox control (1996), has not led to a noticeable increase in quokka abundance or known populations, and all known populations are critically low in number and isolated from other elements of the collapsed metapopulation (Hayward et al. 2003). Foxes remain the biggest mortality source for quokkas (Hayward et al. 2005a). This suggests the metaphorical fence of poison has not been completely effective. Whether this is because foxes have developed a tolerance to 1080 (Hayward and Kerley 2009) or because mesopredator suppression of cats has been released with the lowering of fox density is unknown. In light of the recent precipitous decline of the formerly conservation-dependent woylie to becoming endangered (de Tores and Marlow 2012), there should be concern for the persistence of the quokka, such that consideration should be given to creating a physical fence around some known quokka populations and surrounding swamps.

Are the Fauna of Dwesa and Cwebe Nature Reserves Threatened Because of Ineffective Fencing?

Bushmeat hunting is increasingly becoming a conservation threat (IUCN 2007). Areas where people have relatively easy access to wildlife become halos of defaunation (Wilkie and Carpenter 1999) and the impact of poaching effectively decreases the size of conservation areas in proportion to the area accessible to poachers (Hilborn et al. 2006). These issues suggest Dwesa and Cwebe are providing little value for conservation. Yet many of the species present in Dwesa and Cwebe are grassland species that are unlikely to be there naturally (Hayward et al. 2005c). Thus, their local extinction may not be a critical assessment of the conservation value of the reserves. Other threatened species that do persist in Dwesa and Cwebe (e.g. blue duiker *Philantomba monticola* and samango monkey *Cercopithecus mitis labiatus*) are of more relevance. Blue duikers avoid the roads and tracks used by poachers suggesting they are affected by the ineffective fencing (Hayward 2009b). Conversely, samango monkeys appear unaffected by Dwesa and Cwebe's fencing issues (Hayward 2009b). Thus, there is a suggestion that fencing might be important to conserving blue duikers by minimising risk of poaching.

Furthermore, if the wildlife inside the reserves cause injury or substantial financial damage (bushpigs *Potamochoerus larvatus* already do) to local communities, there may be increasing pressure to reconsider the merits of having a conservation reserve in the area. In the absence of effective fencing, this is more likely to occur. This also suggests that having an effective conservation fence in place is important to the conservation of the fauna of Dwesa and Cwebe.

Would the Reintroduction of Large Predators to Addo Elephant National Park (and the Other Eastern Cape Reserves) Have Been Successful Without Fencing?

Human persecution drove large predators extinct in the Eastern Cape Province of South Africa in the late nineteenth century (Skead 1987). Human persecution has increasingly restricted large predators to isolated conservation areas today. In the absence of fencing, it is likely that the large predators would leave the conservation reserves, kill livestock or people and be killed in retribution. Thus, it is unlikely that the reintroduction of large predators to the Eastern Cape would have been successful in the absence of fencing.

Has Fencing Caused the Isolation of Wildlife in Białowieża's Primeval Forest?

The border fence between Poland and Belarus is a physical structure that unquestionably fragments the forest for large fauna (see Kowalczyk et al. 2012). The habitat clearance to the north, south and west of the forest effectively isolates the fauna of Białowieża from Western Europe. This illustrates how metaphorical fencing, without any conservation goals, can act the same way as a physical structure. Thus, both fencing and habitat clearance have effectively isolated the wildlife of Poland's Białowieża Primeval Forest.

Although fences may ultimately prove to be as much a threat to biodiversity as the threats they are meant to exclude, the biodiversity crisis we are facing means they are likely to be a critically important part of the landscape for many years to come (Hayward and Kerley 2009).

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