Predator-proof fences for biodiversity conservation: some lessons from dingo fences

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ABSTRACT

Using the history of dingo-proof fences in Australia, I show that several key lessons were learnt by pastoralists, but later forgotten and had to be re-learnt. Each has application to current and future proposals to build predator-proof fences for conservation. 1. Feral predators kill and eat native fauna. 2. Predators go under or through fences, or climb fences. 3. Predator-proof fences must be maintained. 4. Maintenance is expensive and must be continued indefinitely. 5. Scalp bonuses do not control predators and are waste of money. Despite some assertions from conservationists, there is no evidence that the motive for building a fence (conservation *versus* growing sheep) is any guarantee of better performance. Proponents of predator-proof fences (and funding agencies) need to ask two key questions. 1. What is the real objective of the fence, and how do we measure its success? 2. What happens if / when the fences are successful? Unless predators are controlled outside the fence, then the enclosure remains a captive breeding zoo which achieves little for conservation at a landscape-scale.

Key words: fence, predator, conservation, captive-breeding, Australia, dingo, barrier fence

"Those who cannot remember the past are condemned to repeat it." (George Santayana 1922, p. 284)

Introduction

One of the least endearing characteristics of Australians is our inability to remember lessons from the past. For some reason, citizens and especially politicians seem to rapidly forget the lessons and are then surprised by a very predictable re-occurrence. A continent-scale example can be seen in attitudes towards recurrent droughts that are such a feature of Australian climate. Despite this, farmers and graziers for nearly 200 years have claimed that these were abnormal, and requested and received government assistance. One consequence is land degradation related to poor management in the recurring droughts (McKeon *et al.* 2004).

Another example is provided by Bauer (1959) who documents a long series of unsuccessful attempts to raise sheep across northern Australia from 1824 to the 1950s. He concludes

> *The principal reasons for the failures have been both environmental and human. On the environmental side are ranged a marked seasonal (and in some places tropical) climate, unsuitable pastures and isolating distance. On the human side the most important factors have been an initial ignorance of the environmental limitations and an almost reprehensible disinclination to learn from experience*. (p. 169)

At first glance these examples appear totally un-related to biodiversity conservation, but the link is forgetting (or worse, wilfully ignoring) history. This is the theme I explore in this paper.

Using the example of dingo-proof fences, I examine the long-term value of the current generation of predator-proof fences in biodiversity conservation. Australia has the most complex set of vermin-proof fences ever erected in the world. Besides the well-known and iconic "Dog Fence" running 5,400 km from the Great Australian Bight to central Queensland (Woodford 2003, p. 1), we currently have 1,170 km of emu-proof State Barrier Fences in Western Australia and 555 km of the Darling Downs – Moreton Rabbit Fence in south-eastern Queensland. In the recent past, a Tick Fence paralleled the eastern section of the NSW – Queensland border to keep tick-infested cattle out of NSW. South Australia and Queensland are divided by thousands of kilometres of private dingo-proof fences, many now derelict, and all states have thousands of kilometres of private rabbit-proof fences, again, many now derelict. In every case, these fences were erected to exclude pests, and in every case history shows that without a commitment to adequate maintenance and without a guarantee of appropriate and indefinite funding, the fences inevitably failed. An exception is the famous Rabbit Proof Fences of Western Australia which are also now derelict except where adapted as the current State Barrier Fences (McKnight 1969). Because rabbits were already beyond them by the time they were completed, they really did not serve their function so the maintenance was irrelevant.

In general I am not concerned here with how to build predator-proof fences. Long and Robley (2004) provide an excellent summary and critical assessment of current best practice and designs. However, I am concerned with what I perceive to be both unspoken and unrealistic expectations of predator-proof fences. The most important is what happens in the long-term (> 50 y) to any animals inside the fence. Unless we find effective means of controlling predators by biological control or poison, such fenced conservation

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reserves will remain captive-breeding zoos for a very select few species. This contributes relatively little to conservation of biodiversity in the wider landscape.

In this paper I use the history of dingo fences to draw five critical lessons for predator-proof fences. Each lesson involved forgetting crucial knowledge that had been acquired expensively by many people, and each is applicable when proposing to build fences for conservation.

Lesson #1: Predators kill and eat prey

Squatters taking up land for their flocks quickly learned that dingoes attacked and killed sheep. The solution was to continue the age-old tradition of shepherding the flocks during the day, and penning them in closely watched yards at night (Pickard in press). The initial solution was strychnine, introduced into Victoria in the mid-1840s, and widely used against dingoes by the early 1850s. Strychnine, and perhaps a plague of canine distemper, effectively eradicated dingoes from south-western Victoria. For this and a range of other reasons (Pickard submitted), squatters here were able to fence and dispense with shepherds.

About 20 years later, pastoralists taking up land in the Mallee of north western Victoria in the 1870s had forgotten the devastating effects of dingoes on sheep.

> *When the pastoral leases … were issued in 1870, a mania for fencing set in over the whole mallee country, and the runs were divided into paddocks of all sizes … into which the sheep were turned out, and allowed to graze at their leisure. The services of shepherds were dispensed with, boundary riders were employed to look after the fences … Since then, however, the wild dogs have become so numerous as to render it necessary to shepherd the sheep and yard them at night.* (Anon 1880, p. 135)

At about the same time in arid South Australia, *Yardea* station was fenced and "the sheep turned adrift but long before the lease expired [in 1888] the proprietors realized that the country was untenable unless some means were adopted to cope with the dingo trouble." (Richardson 1925, p. 13). And near Cobar in NSW, Macpherson (1920) had problems with dingoes when he took up his run in 1877: "… wild dogs were very numerous all over … The nearest 'fenced-in' sheep paddock was at Moolah Station, 40 miles south. Sheep had been turned into this, but, on account of the ravages of wild dogs, they had to be taken out again and shepherded."

These three, widely spaced examples show that forgetting expensive lessons was widespread. It is difficult to understand how pastoralists, who had costly vested interests, could forget that eradication of dingoes was an essential pre-requisite for un-shepherded sheep.

Application to fences for biodiversity conservation

Feral predators (dogs, foxes and cats) eat native wildlife. This is well-known, and is unlikely to be forgotten. However, some supporters of captive-breeding programs seem blissfully unaware that any increase in target species must be placed somewhere, or spend the rest of their life in a cage. It is a bit glib to blithely say "control the predators and then release the threatened animals back into the wild." This works very well in Western Australia where many of the native fauna are resistant to sodium monofluoroacetate (1080), the current poison of choice for cats and foxes. Elsewhere in Australia, 1080 has a greater impact on native fauna and may not be able to be used, making predator control more difficult.

Lesson #2: Predators go under or though fences, and climb fences

Apart from a few paling fences, dingo-proof fences had to await the new technology of iron wire in the mid-1850s, and then steel wire in later decades. In the early 1880s, pastoralists in south-eastern Queensland and northern NSW built "lace fences" to exclude dingoes from their properties (Fig 1, see appendix 1). Most are immediately west of Stanthorpe but they extend south to Tamworth in NSW. Essentially these were hand-made woven fences with multiple line wires linked by vertical wires locally called " braces" (Black 1988, pp. 59-60; and Davidsons of New England Association 1983, pp. 55-56). The numbers of line wires varied from 8 to 16, and the numbers of braces ranged from 5 to over 40 per 3 – 4 m long panel. A few fences had a top barbed wire with the rest plain, and some used alternating plain and barbed wires. These fences were generally less than 1.5 m high, and usually less than 1.0 m (Pickard field data from measured fences). At about the same time, other pastoralists built paling fences to exclude dingoes (e.g. Black 1988, p. 60; Walker 1988, p. 119).

Initially, the fences stopped the dingoes which would not climb them. Unfortunately for the pastoralists, dingoes learnt to get through, under or over the fences. Flint Davidson's battle at *Mount Pleasant* is probably typical.

Figure 1. Some of the earliest extensive wire fences built to exclude dingoes were lace fences in northern NSW and south-eastern Queensland. This well-preserved example, east of Tamworth NSW, was built in the 1880s by Flint Davidson. A total of 14 alternating barb and plain wires are linked by about 30 vertical braces about 130 mm apart. Hexagonal netting at the top and the steel post are recent additions.

Photo: J. Pickard

> *This fence consisted of stout stringybark posts, four feet* [1.2 m] *high with panels ten feet* [3.0 m] *apart. There were thirteen horizontal wires: seven barbed (about 12-gauge) and six plain (about 10-gauge), plus a fixed sapling at ground level. Vertically, there were three lacing wires (about 14-gauge) spaced evenly in each panel and secured to the sapling.*

However, the dingoes climbed through it! So, they added five more vertical lacing wires but the dingoes still went through. More lacing wires were added until one could put only three fingers between each vertical pair. …

The dogs could not now get through the fence but they either jumped or climbed it.

> *Flint then added posts eighteen inches* [0.46 m] *high to the top of the existing ones and fixed wire-netting between them. That stopped the dingoes from climbing or jumping but they scratched their way underneath the ground-level sapling.*

The next move was to discourage this by running a length of barbed wire at ground level alongside the sapling. The dingoes had no answer for that! (Davidsons of New England Association 1983, pp. 55-56.)

Obviously these pastoralists believed their first low lace fences would work, otherwise they would not have invested the time and money in them. When the dingoes learnt to overcome the fences, the pastoralists also learnt, and modified the fences. The cumulative learning through hard experience eventually resulted in a fairly effective dingo-proof fence. Pastoralists built these elaborate and expensive lace fences because, by this time, they knew that paddocked sheep were more productive, had higher lambing percentages, cleaner wool and less disease than shepherded sheep (Gordon 1867, pp. 10-11). Thus the investment made sound financial sense.

However, this does not fully explain why pastoralists chose lace fences instead of wire netting which was being made in Sydney by John Lysaght Ltd from 1884 (Schedvin 1970, p. 28). Wire netting had also been available from Scotland since at least the mid-1850s, when Charles D. Young & Co (post-1851, p. 4 and Plates 1-3) advertised wire netting designed specifically for dog-fences for £147 per mile ($9060 km^{-1} in 2005 dollars, converted using Snooks 1994, table 7.10, extended using data in ABS 2005). Presumably this price was at the Edinburgh works with shipping an additional cost. Black's lace fence on *Wallangra* cost him £91 per mile ($3680 km^{-1}) (Black 1988, p. 60), at a time when the average four plain wire fence in Queensland cost about £50 per mile ($2020 km^{-1}) and a netting rabbit-proof fence £100 per mile ($4040 km^{-1}) if built from scratch, or £80 – £100 per mile ($3230 - $4040 km^{-1}) if netting was added to an existing fence (i.e. £50 ($2020 km^{-1}) plus £30 – £50 ($1210 – 2020 km^{-1}) for the netting).

Regardless of the initial use of lace fences, pastoralists in south-eastern Queensland quickly adopted wire netting and, having learned their lesson, built high fences to exclude dingoes. One example was the boundary fencing of the 9,000 acre (3,642 ha) property *East Talgai* on the Darling Downs:

> *The boundaries are all netted and partly fenced with a kangaroo and dog proof fence, 5 feet 9 inches* [1.75 m] *in height, consisting of netting, a barbed wire, and then two plain wires above – a new kind of fence to me, but a very useful one,* [the owner] *says. I inquired the cost, which he gave as £70 to £100 a mile* [$3280 - $4680 km^{-1}]*, but it was mostly made in days when netting was dearer that it is now.* (R.E.N.T. 1893, p. 326)

Half-way across Australia, pastoralists in South Australia were also struggling against dingoes at the end of the 19th century and in the early years of the 20th. Not only were they fighting dingoes, but they were also fighting each other about the proper height of a dingo-proof fence (McKnight 1969, p. 336). The details of the disputes are no longer relevant here, but they tell us a lot about the behaviour of experienced pastoralists and their (un)willingness to learn from others.

The leading proponent of low fences (< 4', 1.2 m high) was Peter Waite (1834-1922), a very experienced pastoralist. From the late 1860s, in partnership with Sir Thomas Elder and other pillars of South Australian commerce, he owned several large properties in dingo-infested areas of semi-arid South Australia and New South Wales. He developed and implemented a sophisticated system of grazing management using numerous relatively small paddocks (Lange *et al.* 1984) bounded by "lightning fences" he had developed (Pickard 1992). He was very highly regarded by his peers (Hogg 1991) and was a frequent contributor to *The Pastoral Review* from the late 1890s until the 1920s. There was no single champion of high fences (> 5' 3", 1.6 m), rather, several pastoralists responded to Waite's articles and letters describing their own experiences (Table 1).

Officer (1917), whose property adjoined *Momba* (one of Waite's properties in western NSW), stated bluntly that dingoes came over Waite's low fences. Subsequent owners must have agreed because with a few exceptions, the fences were later extended to 6' (1.8 m) high (Pickard 1992 and field data from fence measurements). However to be fair to Waite, he steadfastly argued two important additional points:

- Poisoning and traps both inside and especially outside the fence are essential
- "*… no fence will kill dogs. It can only be a barrier, and call a halt for the dogs, which gives an opportunity to kill them by means of traps and poison. If advantage is not constantly taken to systematically employ these methods of destruction, it is only a question of time when the dogs will get inside either though washaways, rabbit holes, blowouts under the fence, open gates, breakdowns, or drifted sand. Without constant attention no fence is proof against live dogs, …*" (Waite 1913)

By the 1920s, the dispute had fizzled out. There is no doubt that the high and low proponents were experienced graziers. But the costly experience of those who had seen their low fences fail was ignored by those who claimed that dingoes would not climb. Presumably, the "low fencers" had either forgotten, or never knew about the experience in the east at about the same time. But why did they

Table 1. Summary of arguments about low and high dingo-proof fences

State	Time period	Reference
Dingoes don't cross low fences (< 4', 1.2 m)		
South Australia	1886 and 1895	Anon (1906)
	1890+	Waite (1907 and 1913) and numerous subsequent articles and letters from 1914-1917
High fences (> 5' 3", 1.6 m) are necessary		
South Australia	1886-1895	Anon (1906)
Queensland	1880s	Black (1988, pp. 59-60)
	~ 1900	Arthur (1914a, b)
	~ 1900	Kingloc Ltd (1914)
New South Wales	1880s	Davidsons of New England Association (1983, pp. 55-56)
	~ 1900	Marsh (1914)
	~ 1900	Officer (1917)

ignore the experience of their contemporaries? Why did the "low fencers" think that others wasted large amounts of money building high fences? Peter Waite's refusal to accept that dingoes could climb low fences may have been a consequence of his age. Born in 1834, he was 80 years old in 1914 when the controversy about fence height flared up. Perhaps the dingoes were faster learners and more adaptable than some ageing pastoralists.

In the event, most dingo fences were extended to about 1.8 m high by adding marsupial netting (i.e. 100 mm or 4" mesh) to the top of thousands of kilometres of netted rabbit-proof fences. This was generally effective but dingoes had already learnt to exploit the slightest weakness or hole in the fences and pass through or under them. By World War 2, a "typical" dingo-proof fence was about 1.8 m high, with 900 mm wide strip of 100 mm marsupial netting on top, a 900 mm wide strip of 37 mm netting below. The lower edge of the bottom netting would be either folded out about 200 mm or buried about the same distance (Fig. 2). Plain or barbed wires at various heights strengthened the fences. As numerous pastoralists built these fences on their properties, there are many variations, but they do not concern us here.

Although *The Pastoral Review* had been a leading source of information to graziers early in the late 19th and early 20th centuries, its flagship book first published in 1912 (Anon 1912) became very dated by the time of the eighth edition (Pearse 1965). Evan Pearse, retired editor of the *Review*, seems to have made no attempt to introduce current fencing technology into the book. Instead he simply re-used the same tips, hints and techniques from many decades previously. The first part of his advice on dog-proof fencing is bizarre:

> *… there is a marked divergence of opinion regarding what should be the height of the fence. It should be remembered that the natural instinct of a dingo is to get under or through a fence, jumping being an acquired art, and if a 3 ft. 9 in.* [1.1 m] *fence, with a guard wire 3 in.* [75 mm] *above the ground when the soil is loose or sandy, is kept under constant supervision, it should prove an effective barrier. …*
>
> *However, as already stated, opinions differ on what constitutes the most effective dog-proof fence from the point of view of height, and the following is a description of a 5 ft. 3 in.* [1.6 m] *fence as advocated by a leading Western New South Wales grazier:- "The 5 ft. 3 in.* [1.6 m] *height was obtained by using rabbit netting (3 ft.* [0.9 m\]*) and marsupial netting (2 ft. 3 in.* [0.7 m]*) on top."* (Pearse 1965, pp. 72-73)

Figure 2. Government dingo fences very enormously in structure and components. This 1.8 m high section of the NSW Dog Fence on the NSW – Queensland border east of Hungerford is typical of modern versions of non-electric dog fences. It is designed to keep dingoes in Queensland (on the far side of the fence) from entering NSW. In this section, the lowest netting is folded along the ground forming an apron, weighted down with logs to provide a floodgate for irregular water flow in intense storms. Elsewhere the apron is pegged and buried. The well-graded access tracks are essential for regular inspection patrols and maintenance.

Photo: J. Pickard

Why Pearse re-used woefully out-of-date and proven incorrect information is unknown. He was born in 1892 and was editor of the *Review* from 1917 to 1951 (Walsh 1993, p. 253) and perhaps like Peter Waite, he was too old to keep abreast of current technology and approaches.

Application to fences for biodiversity conservation

If fences are to be used to exclude predators, then the best available design, based on hard experience is essential. Anything less is a waste of money. The current designs for cat- and fox-proof fences (Long and Robley 2004, Table 3, Catalogue of fence designs) are designed specifically to counter the ability of both predators to climb fences or dig under them. The top overhang and multiple electric wires have proved effective, at least in the short-term (Fig. 3). But Long and Robley's list of recommended research sounds a note of caution: many critical aspects of design have not been rigorously tested. Indeed, such lack of testing and proper experimentation is a recurring and disappointing theme of attempts to control feral animals for biodiversity conservation (Reddiex *et al.* 2004).

Figure 3. Total feral exclusion fence protecting a remnant patch of mallee south-east of Nhill in western Victoria to allow breeding of mallee fowl is an excellent example of current designs and construction. The fence is 1.8 m high with a 0.35 m outward overhand at the top. Two solar-powered 6,000 volt electric wires on fibreglass stand-offs deter foxes and cats from climbing the netting, and a third electric wire on the outer edge of the overhang completes the defence. The lowest netting is laid outwards forming an apron to deter digging by rabbits and foxes. The 13 km long fence is privately owned and was built in 2000 with some support from the National Heritage Trust at a cost of $36,300 km^{-1}. Regrowth shrubs close to the fence will pose maintenance problems.

Photo: J. Pickard

Although George Santayana (1922, p. 284) was correct about repeating history, current interest in feral fences provides two examples where previous experience and knowledge was not entirely helpful. When the exclusion fence was built around the Arid Recovery Project at Roxby Downs, 40 mm (1.57") rabbit netting was used (Arid Recovery Project 2005). This is about the same size as mesh recommended after exhaustive enquiries in the late 1880s and 1890s. The 1890 *Rabbit Royal Commission* concluded that 1 5/8" (41 mm) mesh "forms a practically efficient barrier against the incursions of rabbits." (p. xxxi). Despite this, in February 1888, the NSW government had changed the maximum mesh size for subsidies from 1 5/8" (41 mm) down to 1 ½" (38 mm) and many witnesses at the Royal Commission stated that 1 5/8" (41 mm) was too big. Unfortunately at Roxby Downs, rabbits got through the 40 mm mesh, and it was replaced with 30 mm (1.18") netting. This is even smaller than the 1 ¼" (32 mm) suggested by some graziers in the 19th century. Here, it is clear that lessons learnt from previous experience may not be directly applicable when a fence is used for a different purpose.

The second example concerns the optimum height of a dingo fence. Long and Robley (2004, p. 38) recommend further research to "determine the propensity of dingoes and wild dogs to jump fabricated and netting fences of varying heights to identify an optimal fence height." This was precisely the argument that raged in *The Pastoral Review* over 90 years ago. Given the tens of millions of dollars spent on dingo fences in Australia over the last 50 years, this recommendation is startling. While it may appear to confirm my thesis of forgetting lessons, I believe that it provides an excellent illustration of the best of current thinking: accept information from the past, but test it rigorously to get the optimal specifications for the job in hand.

Finally, it is worth remembering that conservation fences may have to resist other animals besides predators. Central Australia is infested with feral camels which are notorious for running at high speed through fences. I have seen many panels of 1.8 m high dingo-fences almost flattened by camels on the southern edge of the Great Victoria Desert of Western Australia. Any predator-proof enclosures in these areas would need fences sufficiently strong to resist rampaging camels, and to date, such fences have not been developed on a large-scale in Australia.

Lesson #3: Predator-proof fences must be maintained

Almost as soon as pastoralists erected dog-fences, maintenance became a problem. Shrubs and trees grow up between the netting, floods wash out the fences, burrowing native animals (e.g. echidnas and goannas) create small holes which are exploited by e.g. wallabies and feral predators to create large passages, sand buries the fences, etc. Despite being proven wrong about fence height, Peter Waite (1913) was correct in his repeated insistence on maintenance. Lack of maintenance, perhaps more than anything else, causes fences to fail. Even as late as 1966, the Queensland government had to "pressure" some landholders into repairing the recently completed State buffer fence and making it dingo-proof.

The time taken for the fence to fail varies with terrain, flood damage, falling trees, etc. Whether the failure is serious depends on the particular fence, the nature of the breach, how long before it is repaired and the numbers of unwanted animals able to use the breach. One or two non-breeding predators *may* make little difference, but a large number of both sexes could have serious consequences with a rapid build-up of numbers inside the fence.

Application to fences for biodiversity conservation

Any fence needs maintenance, without it the fence rapidly becomes an expensive collection of steel and wood interrupting vistas of the landscape. There are good reasons why the major vermin-proof fences today are all managed and maintained by government agencies. The prime one is that history has repeatedly shown the reluctance of many pastoralists to adequately maintain the fence where it bounds their properties. Similarly, there are good reasons why access roads are cleared on both sides of major fences, and the fences are regularly sprayed with herbicide to reduce regrowth along the line of the fence. If the fence is electric, then routine and regular spraying is essential. While this may seem undesirable to some ultra-hardline conservationists, they need to ask themselves if they want the fence to fail prematurely.

Long and Robley (2004, pp. 13-14) list some of the likely maintenance issues that can arise. But there is no long-term experience with the newer designs of predator-proof fences incorporating a mix of high netting and high voltage electric wires (Fig. 3). Farmers and others have decades of experience with electric fences, and know only too well that they are efficient and cost-effective, but rapidly have maintenance problems with regrowth of shrubs, grass, etc. This is one area of design that needs careful monitoring and testing.

Re-introductions of large carnivores (bears, wolves and lynx) in several European countries have stimulated interest in fences to keep these carnivores away from domestic stock. Although the threatened status of predator and prey is reversed in Australia, the objective is essentially the same: conserve threatened species. Interestingly, maintenance is only briefly mentioned in several papers (e.g. Levin 2000, 2002; Angst 2001, Wam *et al.* 2004).

Lesson #4: Maintenance is expensive and must be continued indefinitely

As a consequence of the reluctance of many pastoralists and graziers to commit adequate funds and time to maintenance, all current dog fences in Australia are maintained by government agencies. Current funding arrangements vary, but typically involve contributions from landholders who benefit, and general State Treasury revenue. Directly comparing the maintenance costs of these fences is difficult because they serve different purposes (Queensland, NSW and South Australia: dingoes; Darling Downs-Moreton: rabbits; WA: emus) and thus have different physical structures, and also because the responsible agencies have different responsibilities and different methods of apportioning costs. However, it is instructive to look at general patterns in the annual maintenance costs (Fig. 4)

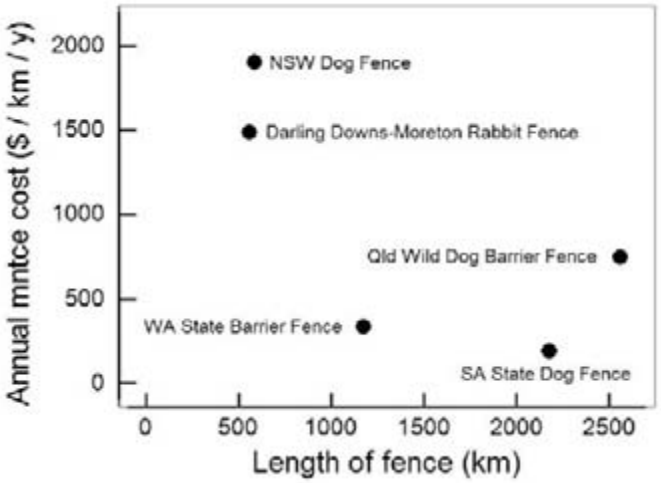

Figure 4. Annual maintenance costs (financial year 2004-2005 except WA: 2003-04) for major Australian vermin-proof fences.

Sources: personal communications (April - May 2005) with NSW Wild Dog Destruction Board, Darling Downs-Moreton Rabbit Board, South Australian Dog Fence Board, Western Australia Agriculture Protection Board, and Queensland Department of Natural Resources and Mines.

There is a flag-fall of maintenance costs of around $1,500 km^{-1} on fences shorter than about 500 km, but the costs fall rapidly to less than $400 km^{-1} on fences over 1,000 km long. The higher cost for the Queensland Wild Dog Barrier Fence are probably due to considerable distances of rough and forested terrain crossed by the fence.

Application to fences for biodiversity conservation

Maintaining predator-proof fences is expensive, essential and perpetual. Extrapolating from the major vermin-proof fences, annual maintenance costs are likely to be over $1,000 km^{-1} on fences shorter than 500 km. I know of only one robust attempt to estimate maintenance costs of conservation fences *before* erection. Brook *et al.* (2004) suggest that the *minimum* annual maintenance costs of a 6 km fence to exclude cane toads from Cobourg Peninsula in the Northern Territory would be almost $70,000 km^{-1}. Such massive perpetual expense would make any funding agency draw a deep breath.

Lesson #5: Scalp bonuses do not control predators and are a waste of money

Although not strictly related to fencing, it is essential to consider the question of scalp bonuses as they are often suggested as part of an integrated control program for vermin. In earlier times, professional rabbiters and doggers were paid scalp bonuses. Despite governments

and pastoralist organisations paying out huge sums in total for huge numbers of scalps, both rabbits and dingoes increased in numbers (e.g. see evidence in the Rabbit Royal Commission 1890). Rabbiters and doggers had no interest in eradicating or substantially reducing their target populations. To do so would increase the effort to make an income, or worse, deprive them of income altogether.

Today, despite being discredited by most analysts as ineffective in controlling vermin, scalp bonuses are still paid in several states on a range of species. The justification seems to be to allow the landholder to defray some of the costs of trapping vermin.

Application to fences for biodiversity conservation

So-called "sporting shooters" have long argued that they contribute significantly to conservation by killing a range of exotic animals (pigs, foxes, deer, etc.) They also argue that they should be allowed access to conservation areas to help control predators in them. However, there is no evidence that such desultory, uncontrolled and fragmented shooting achieves anything for conservation. There is little evidence that shooters target small or young animals. On the contrary, a casual glance at any of the magazines for the shooting fraternity shows that large "trophy" male animals are preferred rather than breeding females. Finally, it is relatively easy to demonstrate that populations of animals with large litters and short gestation periods (e.g. cats, foxes and pigs) can quickly recover even after losing 90% of their populations.

Amateur shooters, like those who sought and were paid scalp bonuses, have no interest in seeing target populations either eradicated or controlled. To do so increases the effort per unit trophy kill, and can make the whole exercise too expensive, time-consuming and unattractive to amateurs.

Some questions that arise

1. Do motives matter?

Every pastoralist and farmer who ever built a rabbit- or dog-proof fence genuinely believed that it would be vermin-proof for many years. They were investing money to achieve a management goal of better income. Conservation fences have a quite different rationale: saving some threatened species from extinction, a motive regarded by some as purer than mere money-grubbing.

In private discussions with conservationists, my concerns about predator-proof fences have sometimes been dismissed with a moral high ground assertion. Typically, this takes the form of "oh, but we are not motivated by money, therefore we have greater commitment to the fence and its success". While I don't doubt the commitment, I see no logical reason why it will ensure success of the fence, which after all, is a rather inanimate object, and thus unable to detect the motives of the fence builders. More accurately, the argument suggests that builders of conservation fences are more likely to ensure continued and continual commitment and maintenance. Again, I see little historical evidence to support this assertion.

The Arid Recovery Project at Roxby Downs, the largest uranium mine in Australia, is a collaboration between mining company BHP Billiton, the South Australian Department of Environment and Heritage, University of Adelaide and Friends of Arid Recovery. An impressive fence surrounds 60,000 ha of arid environment that is now free of all feral predators and domestic herbivores. Inside the fence, the vegetation is recovering and several threatened species introduced into various enclosures are happily reproducing. By any measure, the Project is successful. But consider what happens when the mine inevitably closes, and (most likely) the town is removed lock, stock and barrel as often happens in such isolated areas. With no on-site staff, and no money from industry, will the project continue? Will the same level of maintenance be guaranteed? The limited success of current activities is no guarantee that the enthusiasm will continue indefinitely.

The Landcare movement in Australia has been hailed as one of the greatest advances in rural landscape management in two centuries. Governments have poured billions of dollars into myriad local and uncoordinated projects, each proposed and carried out by local groups of concerned landholders. However, an outside observer could be forgiven for thinking that the enthusiasm was directly proportional to the money available, and in any event, the bubble of enthusiasm burst within a decade. Finally, one very dispassionate observer, the Australian National Audit Office, criticised the lack of meaningful performance indicators in early Landcare projects. Thus the total length of fences erected to protect vegetation or riparian zones actually tells us nothing about the success of the real objective: regeneration of the vegetation and remediation of riparian zones (ANAO 1996-97). More recently many of these issues have been addressed, but some of the performance measures still do not measure anything of real interest. Specifically there is great cause for concern about the lack of co-ordination between projects, and the minimal likely benefit at a landscape-scale.

I see no reason for complacency about fences built specifically for conservation. Enthusiasm and commitment are essential to get a project going, but the long-haul of maintenance over perhaps decades may well dampen the enthusiasm, especially if (or when) short-term funding ceases. Thus it is facile for conservationists to suggest that their fences will work because they are motivated by conservation goals.

2. What is the real objective of the fence, and how do we measure its success?

Typically, feral-proof fences are designed to exclude feral predators from a larger or smaller area to protect vulnerable species inside. At the same time, the fence has to prevent the target species from escaping. More specifically, Long and Robley (2004, p. 2) suggest that

> *The general assumption behind constructing a fence is that it will protect or facilitate a recovery in a specified environmental value by preventing feral pest species reinvading an area once they have been eradicated, thus reducing the long-term costs associated with on-going pest control. If eradication of the pest species within a given area is not the necessary outcome, alternative approaches to building a fence should be explored.*

It is not trivial to ask what a project intends to achieve. Building feral fences is a tool, a means to some end. What exactly is the end? Is it a perpetual captive-breeding program inside a large cage, or is there some likelihood of release into the wild? What *exactly* will be achieved with the money? Funding agencies (e.g. the National Heritage Trust and its successors) need to ask very detailed and specific questions to ensure that those requesting funds for predator-proof fences fully articulate the tangible objectives of their proposal, and in particular, spell out very clearly the source of perpetual funds for maintenance. If the latter is obscure or unknown, then the funding bodies would do well to not fund the request.

3. What happens if / when the fences are successful?

Many / most of the areas protected by predator-proof fences are, in essence, open-range zoos that serve two overlapping primary functions:

- captive breeding of threatened species, hopefully for later release in the wild, and
- protecting small populations in imminent danger of extinction until long-term control of the predators is achieved.

An important question arises from the first function: what happens if / when the breeding program is successful? Do we release the offspring into the wild, or retain them in our expensive zoo? Re-introduction onto off-shore islands has been successful in South Australia and Western Australia, but these are exceptions. Most government conservation agencies are reluctant to be involved in captive breeding on mainland Australia. They are even more reluctant to be involved in programs of release of captive-bred threatened species back into the wild. The reason is fairly simple. Without a guarantee of essentially perpetual and predicated funding to either maintain predator-proof fences, or maintain intensive baiting programs, the released animals are simply a smorgasbord for cats and foxes. If this were to happen, the public outcry would be enormous and justified. Consequently, in NSW at least, the only official release sites are in reserves where there is already an on-going intensive baiting program (e.g. Yathong Nature Reserve), and even there, many agency staff have severe misgivings about the long-term value of such releases (based on first-hand experience and numerous discussion with staff while I was employed as Manager Conservation Programs and Planning, Western Directorate, NSW National Parks and Wildlife Service 2000 - 2002). There is no sign that any state government (or the Commonwealth) is willing to embark on wild releases on the mainland. This acknowledges that such releases would be certain failures.

A cautionary tale comes from the successful Arid Recovery Project described above. In June 2004, 12 bilbies were released outside the fence as a trial.

> *After baiting for feral predators, 12 bilbies, of mixed age and gender, were released on the other side of the fence. Seven bilbies succumbed to predation by feral cats. These unfortunate results illustrate the need for the development of effective broad-scale feral cat control, if bilbies are to survive in the region without exclusion fencing. Four bilbies were still known to be alive at 100 days post-release (two male, two female) with one female having produced three young. This project is still in progress with the survival of the remaining bilbies being monitored daily.* (WMC Resources 2005)

Twelve months later, two animals were known to have survived, and a number of others have dug out under the fences (Arid Recovery 2006).

The only other practical justification is that the predator-proof fences buy time until other longer-term control methods are developed. If we take the example of feral rabbits in Australia, this took almost 80 years until myxomatosis was developed and released in the 1950s, and another few decades until the release of rabbit calicivirus disease in the 1990s. Which raises the question of how long before some effective control is available for cats and foxes. Another way of stating this is to ask how long the captive-bred populations will need to remain in their (larger or smaller) cages. And who is going to pay for what may be decades of maintenance?

Repeatedly forgetting expensive lessons. Will we ever learn?

Australians are not stupid, but an external observer could be forgiven for thinking they are. What other explanation can be offered for the repeated forgetting of expensive lessons?

- *Predators kill and eat prey*. Forgotten in the 1870s when widely separated areas of south-eastern Australia were settled and fenced, but dingoes were not controlled. Pastoralists had to go back to shepherding.
- *Predators climb fences and go under or though fences*. Learned independently through expensive experience in the 1880s. Despite this, some pastoralists in South Australia argued until at least 1917 that low fences were effective. Eighth and last edition of a (once-) respected reference book for sheep growers even suggested in 1965 that low fences were effective against dingoes.
- *Vermin-proof fences must be maintained*. Stated over and over by Peter Waite and others in the early 20th century, but forgotten (or ignored) by later pastoralists in both South Australia and Queensland.
- *Maintenance is expensive and must be continued indefinitely*. Without a guarantee of adequate funds for an indefinite period, then a predator-proof fence is enclosing a very short-term zoo.
- *Scalp bonuses don't work and are incredibly expensive*. Known since the late 1880s, but dingo bonuses are still paid. Another manifestation are current calls from "sporting" shooters for access to conservation areas to control predators.

If we look at the most recently proposed fence – for cane toads in the Northern Territory - it is easy to see that many of these lessons were being ignored by the proponents. Cane toads are moving west across northern Australia, and causing havoc with native fauna. The

Legislative Assembly of the Northern Territory established an enquiry into the toads, and possible control methods (L.A.N.T. 2003). Various public submissions contain all the old shibboleths: build fences, use scalp bonuses, etc. Fortunately saner heads prevailed, and no fences were initiated. Brook *et al.* (2004) looked very closely at a proposal for what appears to be a very efficient fence: 6 km across Cobourg Peninsula, thus isolating 2,207 km^2. However, they found that even this short fence would cost a *minimum* of \$600,000 km^{-1} to erect with annual maintenance costs of almost \$70,000 km^{-1}. And in any event, the fence would not be effective because cane toads can swim in salt water around the end of the fence! So much for the cries for fencing Cobourg Peninsula.

Conclusions: asking the right questions

Erecting a predator-proof fence is a relatively straightforward, albeit expensive task, and one that is eminently satisfying. A modern cat-proof fence with all its netting, 2 m high posts, overhangs and electric wires is a sight to behold (Fig. 3). It is also a tangible sign that "something is being done", and thus can be of great benefit in involving the wider community. But the fence is just a tool, not an end in itself, so we need to look more closely at its purpose. Given the current interest in predator-proof fences, I believe that funding agencies need to look very hard and very closely at requests for funding. Very specific questions need to be asked to explore a range of longer-term issues:

- How long will the project last? Typical three- or five-year funding is pointless because of problems of wild release.
- What will happen to the captive-bred animals?
- What happens if the predators outside the fence can not be controlled for decades?
- What is the fence maintenance protocol and budget? Is this budget realistic and based on experience with other similar fences?
- How will maintenance be audited?
- What is the contingency plan if / when the fence is breached and some predators enter the enclosure?
- Is private land to be fenced? What happens when it is sold? In general, I do not believe that any of the current government / private agreements about conservation offer robust long-term environmental protection. Perpetual covenants on title showed promise, but there is little evidence that incoming purchasers are prepared to honour them, and even less evidence that the responsible government agencies have the resources to audit this. As a consequence, funding agencies should think very carefully before funding predator-proof fences on private land, and in most / all cases reject the applications.

I will close by returning to Peter Waite (1913) who would not accept that his low fences didn't work.

> *… no fence will kill dogs. It can only be a barrier, and call a halt for the dogs, which gives an opportunity to kill them by means of traps and poison. If advantage is not constantly taken to systematically employ these methods of destruction, it is only a question of time when the dogs will get inside …*

The lesson here, if we don't forget or ignore it, is clear: predator-proof fences only provide an opportunity and time for other action. Whether we use that time profitably is up to us.

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