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Ecological connectivity or Barrier Fence? Critical choices on the agricultural margins of Western Australia

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Western Australia's State Barrier Fence represents a continuation of colonial era attitudes that considered kangaroos, emus and dingoes as vermin. Recent plans to upgrade and extend the Barrier Fence have shown little regard for ecological impacts or statutory environmental assessment processes.

Key words: *barrier fences, corridors, Dingo, ecological connectivity, Emu. Great Western Woodlands.*

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Figure 1. Emus may be only one of many species of native fauna whose population movements are affected by Western Australia's State Barrier Fence. When massing at the fence in the past, Emus have been shot, poisoned or left to starve in the tens of thousands. This problem is likely to be exacerbated by extending the fence. (Photo WA Department of Agriculture and Food.)

Introduction

Fragmentation of primary habitats is one of the major drivers of species' declines and extinctions (Fahrig 2003; Fischer & Lindenmayer 2007; Gibson *et al.* 2013). Fragmentation occurs when remnant habitat is left isolated and the matrix is converted to other uses or from the construction of barriers such as fences or roads that impede the movement of individuals (e.g. Forman *et al.* 2003; Krausman & Harris 2011). As such, removing barriers and restoring destroyed or degraded matrix to increase habitat connectivity represents one of the most tractable ways to improve population viability over the long term (Lindenmayer *et al.* 2008). The increasing role in conservation programmes of connectivity conservation, through what are often popularly called 'biodiversity corridors', to reconnect

landscapes (Soulé & Terborgh 1999; Fitzsimons *et al.* 2013) therefore represents an important progression from earlier focuses on protected areas that by themselves are not sufficient to retain biodiversity (e.g. Laurance *et al.* 2012).

Connectivity conservation recognises the need for integration and cooperation across different land uses (Worboys *et al.* 2010; Fitzsimons *et al.* 2013). There has been a rapid growth in the development and implementation of on-ground connectivity conservation initiatives in Australia, ranging from large subcontinental corridors to more regional initiatives (Fitzsimons *et al.* 2013). Despite this enthusiasm and the successes achieved, programmes to increase ecological connectivity inevitably come up against proposals, which if implemented, are likely to reduce connectivity.

In this review, we describe one such situation where hard-won conservation gains are now being threatened by a proposal to extend and upgrade an existing barrier fence designed to restrict Emu (*Dromaius novaehollandiae*) and Dingo (*Canis dingo*) distributions (Figure 1). The Government of Western Australia proposes to extend the existing fence some 650 km, from 1170 km to >1870 km. We contend this will seriously constrain terrestrial native mammal and Emu movement between south-western Australia and the rest of the continent and have wider ecological consequences. The proposed extension would also bisect the eastern end of Gondwana Link (Figure 2), the first large connectivity programme established in Australia (Bradby 2013) and recognised as one of six 'foundation stone' corridor endeavours in Australia (Australian Government 2012). We first describe the history of wildlife management using barrier fences in Western Australia, discuss their likely ecological impacts and then outline the process that has led to the planned extensions being considered without a full understanding of their negative ecological impacts.

Western Australia's barrier fence network

Western Australia's barrier fence network was initially established to prevent rabbits, introduced into eastern Australia and rapidly spreading westward, from reaching the main farming and grazing areas of Western Australia. The first fence – No 1 Rabbit Proof Fence – was constructed between 1902 and 1907 from the south coast to the Pilbara coast north of Port Hedland (Crawford 1967). Even before construction was complete, rabbits had breached the barrier and in 1904 work began farther west on a No 2 Fence (Figure 3).

Major deforestation across south-western Australia, largely to establish broad scale wheat growing, accelerated after 1918 (Jasper 1984; Beresford *et al.* 2001; Bradshaw 2012). Sections of the fence prevented Emus from trampling some, but not all, of the new wheat crops. In 1932, the Commonwealth Government tried unsuccessfully to 'control' Emus by engaging military personnel from the Fifth Military District using Lewis Machine Guns. This became known as the 'Emu Wars' and has received national derision (Marshall 1966; Serventy & Whittell 1967; Johnson 2006).

The fences were maintained, somewhat haphazardly, until the early 1950s, when they became officially known as 'Vermin Barrier Fences'. Their effectiveness as a barrier against migrating Emus led to the addition of sections around the north-eastern Wheatbelt in the late 1950s and early 1960s, on the advice

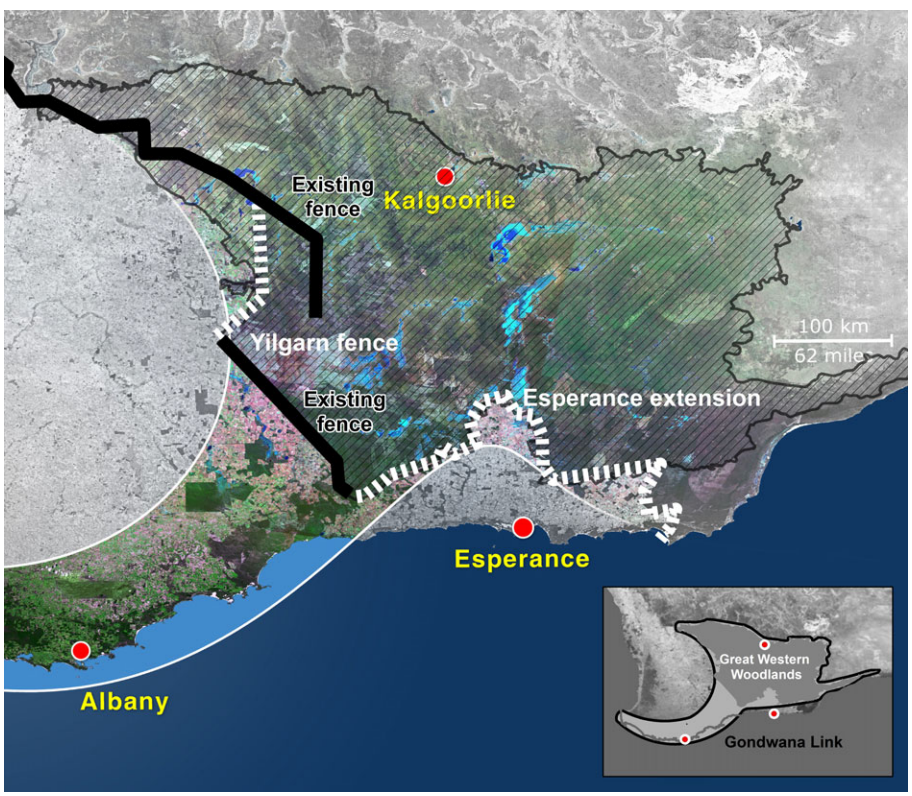

Figure 2. Existing (solid black line) and proposed (dashed white line) state barrier fences in the Great Western Woodlands and location across the broader Gondwana Link. (Fence locations adapted from Redman & Faragher 2010).

of the Western Australian Government's 'Emu and Grasshopper Advisory Committee' (Crawford 1967). Expansion of the Wheatbelt during the 1950s and 1960s (Jasper 1984; Beresford *et al.* 2001; Bradshaw 2012) made No 2 Fence largely redundant, and farms were established beyond the central and southern sections of No 1 Fence in the 1960s. Continued expansion of agriculture eastward was planned, but stalled in 1969 following a series of dry years and a global wheat surplus (Beresford *et al.* 2001). Further expansion became subject to a moratorium in 1985 following increased public concern about the agricultural marginality and high environmental values of areas being allocated for agriculture (Beresford *et al.* 2001).

Today, while the fence has remained largely intact in its northern sections, southern sections adjoining what is now known as the 'Great Western Woodlands' only exist in portions. From the 1980s onwards, these have been maintained as a barrier against Emu and Dingo movement onto farmland. However, trapping, poisoning and shooting Dingoes continued as a supplementary control measure, often on both sides of the fence.

Negative ecological impacts

The barrier fence network originally consisted of rabbit-proof mesh (mesh size ~3 cm across). This has now been largely replaced with 10-line fabricated netting (mesh size ~18 × 12 cm) with 1–2 wires, often barbed, along the top and a mesh 'lap wire', again of fabricated netting, buried in the ground and extending 450 mm from the fence. A 10-m cleared access track is maintained on either side of the fence (GHD 2012). Native vegetation on public land within 1–200 m of one side of the fence is often cleared of trees and shrubs by 'chaining' (a heavy chain dragged between two widely spaced bulldozers) followed by occasional burning to reduce flammability (GHD 2012). This vegetation clearing, accompanied by installation of access and maintenance roads for the length of the fence, is likely to be a barrier for the smaller species for which the fence itself is not a barrier (Brooker *et al.* 1999). A 'buffer zone' that can extend more than 15 km on either side of the fence is subject to an intensive Dingo and feral dog eradication programme using baiting, trapping and shooting (DAFWA undated) which enhances the barrier effect. Thus, the ecological impacts of the State Barrier Fence and associated works to control wildlife are likely to go far beyond the fence line.

While some research has been published to quantify the ecological impacts of fences in Australia (e.g. Pople *et al.* 2000; Somers & Hayward 2012) and elsewhere (e.g. Flesch *et al.* 2010; Lasky *et al.* 2011; Woodroffe *et al.* 2014), the potential impacts of the Western Australia barrier fence on native ecosystems are poorly studied. We therefore provide an evidence-based review of the likely or plausible impacts of the barrier fence and its proposed extension.

Loss of connectivity

Some porosity is inherent across almost any fence. Apart from Emus, most birds can fly over fences and reptiles can generally climb through or over the mesh, as can mammals below a certain size (depending on the mesh type used). Western Australia's barrier fences are specifically designed to restrict the movement of large macropods, particularly Western Grey Kangaroo (*Macropus fuliginosus*), Red Kangaroo (*M. rufus*), Emus and Dingoes. Given the mesh sizes used, medium-sized macropods, such as Black-gloved Wallaby (*M. irma*) and other smaller wallabies surviving in remnant populations, are also unlikely to move across the existing fence and any future extensions unless it is breached by floods or windstorms. The fence might also impede the movement of Short-beaked Echidna (*Tachyglossus aculeatus*). Fence impacts on these and even smaller mammals have not been measured. For species such as the Black-gloved Wallaby, where long-term persistence depends on access to sufficiently large patches of suitable habitat (Courtney 1994; Short & Parsons 2004), reduced access to patches of available habitat could increase the risk of localised extinctions of populations. Given its design as an impermeable barrier to larger wildlife, it is likely that the fence and its extensions also increase the mortality of wildlife fleeing large wildfires.

Little is known of the fence's wider ecological ramifications, such as disruption to the long-range movement of the target species, which is important for maintaining genetic adaptability particularly in light of climate change (Frankham *et al.* 2014). The possible exception is with Emu populations, about which more is known. URS (2007, p. 5-1) in their *Benefit–cost Analysis of the State Barrier Fence* noted that '... there is a definite movement of Emus southward in winter and northward in summer. At this time, Emus will travel up to 1000 km'. When these southward-moving Emus reach the Barrier Fence, they have been shot, poisoned or left to starve in the tens of thousands (APB 2001; Johnson 2006) (Figures 4 and 5). This problem is likely to be exacerbated by extending the fence.

Feral-proof fences have recently been established around a number of large private protected areas, usually to protect small mammals from predators such as feral Cat (*Felis catus*) and Red Fox (*Vulpes vulpes)* (e.g. Moseby *et al.* 2009). As with barrier fences these aim to keep particular species on one side of the fence, but there are many important differences. Feral proof fences target invasive species

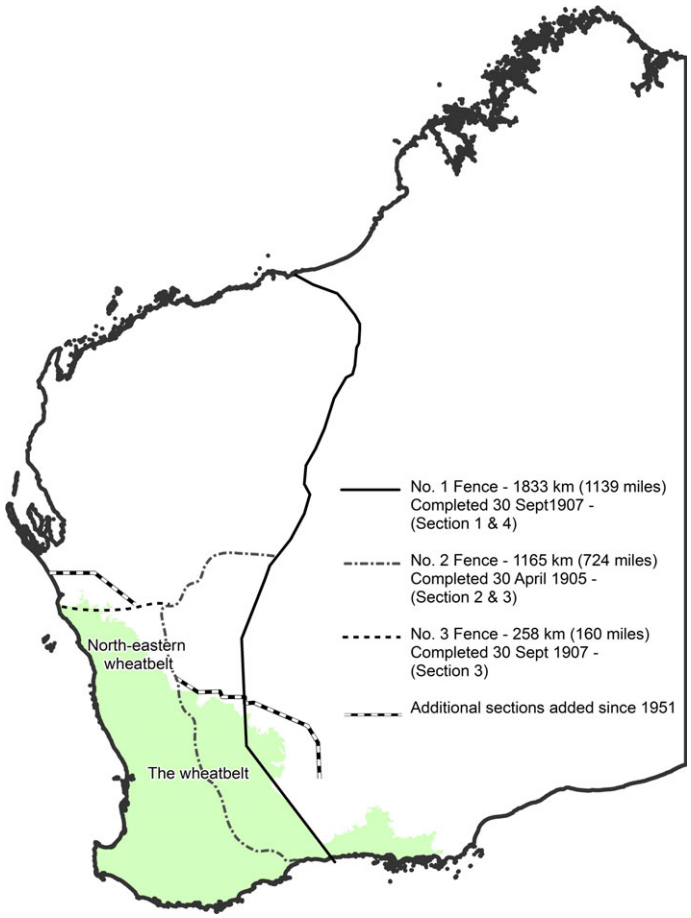

Figure 3. Locations of the original Rabbit Proof Fences in 1907 and subsequent major extensions (adapted from Agriculture Protection Board 2001). Shaded area represents cleared areas.

Figure 4. Parent and chicks separated by the Western Australian State Barrier Fence on the Karroun Hill Nature Reserve boundary. (Photo Andrew Hobbs.)

not native wildlife. They establish 'enclosed islands' around which species can move, so only negatively impact localised connectivity, and they can have ecological benefits. Barrier fences traverse large distances and are specifically designed to prevent wildlife movement at regional and continental scales.

Damage to ecological functions

Restricting genetic transfer

The Emu is an important seed disperser and can have strong influences on the diversity of vegetation by carrying many seeds long distances (Noble 1975; Calvino-Cancela *et al.* 2006; Dunstan *et al.* 2013). The germination of some seeds is also helped by their passage through the Emu's gut (Noble 1975; Noble & Whalley 1978). Chalwell and Ladd (2005, p. 446) note that for many areas '. . .the restriction of the range of Emus as a result of agricultural development, a key seed disperser has been lost'.

Trophic imbalance

Barrier fences are generally justified by the extent to which they reduce the impact of predators (Dingo and feral Dog, *Canis familiaris*) and herbivores (Emu and kangaroos) on crop and livestock production (Letnic *et al.* 2011a). These have potential to be contradictory roles because the Dingo is effective in reducing the density of native herbivore populations that might otherwise increase and overgraze pastoral areas (Ritchie & Johnson 2009; Letnic *et al.* 2011a; Letnic *et al.* 2012).

Mesopredator release

Barriers constructed to impede Dingo movement, which limit Dingo population growth and size on the agricultural side of the barrier, also lessen the important benefits of intact and functioning packs of Dingo in reducing feral Cat and Red Fox abundance. This in turn reduces the negative effects of these feral species on native wildlife, particularly on small to medium-sized mammals (Ritchie & Johnson 2009; Letnic *et al.* 2011a,

Figure 5. Dead Emus along the Western Australian State Barrier Fence. (Photo Graeme Chapman.)

2011b). This is unlikely to affect areas inland of the fence, although associated Dingo control programmes could be responsible for increasing feral predator abundance there.

Adaptability to climate change

Reducing wildlife connectivity, including that of Emus, inhibits the flow of genetic material, and further undermines the resilience of biota to adapt to climate change (Frankham *et al.* 2014). Additionally, the changes in vegetation structure predicted under conservative projections of climate change for this area (Schut *et al.* 2014) could make the perceived optimal location for any barrier likely to change.

Direct habitat loss

Each kilometre of the barrier fence (and associated roads) occupies a footprint of around 2 ha, based on a 20 m width (GHD 2012). Early evidence of high species richness, localised endemism and high heterogeneity in the plant species composition of vegetation communities and habitats across inland south-western Australia has been confirmed in recent years by Hopper and Gioia (2004). The proposed fence extension will result in a substantial footprint to accommodate its linear infrastructure, and this will further reduce already diminished habitat types and damage restricted and/or endangered plant communities and species, many of which have not yet been described.

Fragmentation and subsequent weed invasion of previously intact systems

The current barrier fence appears to have been responsible for only a few sporadic weed infestations, generally associated with camping areas and water points. However, it was constructed in an era when invasive weeds were less prevalent. With fence construction for the proposed extensions, 'Weed invasion has the potential to be a serious issue' (GHD 2012, p. 29), and new weed outbreaks have already resulted from contractors constructing access lines for government agencies elsewhere in the woodlands (Rob Trenordan, Granite-Woodlands Conservation Action Plan team, pers. comm.). Weed seeds are also likely to drop from machinery involved in ongoing maintenance of the proposed extensions and would be well positioned to colonise the disturbed areas associated with the fence, such as adjoining firebreaks and access tracks. Additional risk could exist from invasive Buffel Grass (*Cenchrus ciliaris*) and African Lovegrass (*Eragrostis curvula*), which are relatively recent arrivals and appear to be converging on the Great Western Woodland in particular a convergence likely to accelerate with climate change and lead to detrimental changes in fire regimes (Prober *et al.* 2012).

Little public consultation and science in the proposed barrier fence extension

Despite widespread concern about the ecological damage caused by barrier fences (e.g. CCWA 2012; Burton 2013) and the uncertainty over their economic value (e.g. Hayward & Kerley 2009; Flesch *et al.* 2010; Lasky *et al.* 2011), there has been an apparent reluctance at both political and departmental levels to engage meaningfully with these issues.

From publicly available documents, it appears that a Western Australian Department of Agriculture and Food (DAFWA) project to upgrade the current barrier fences was being developed by 2007 (URS 2007) and that between 2008 and 2010, political decisions were made to enclose south-western Australia behind one continuous barrier fence. The initial documented step was a broad cost–benefit study commissioned by DAFWA '... to investigate the potential of upgrading the SBF (State Barrier Fence) to a wild dog fence that would keep both emus and wild dogs out of the agricultural region' (URS 2007, p. 8). This assessment considered the agricultural effectiveness of the barrier fence against three 'target species' – kangaroos, 'wild dogs' (i.e. the Dingo and feral Dog) and Emu. In terms of ecological issues and non-target wildlife species, consideration was limited to a brief, two-sentence statement that a staff member at the then Western Australia Department of Environment and Conservation '... suggests there is little adverse impact on non-target native species' (URS 2007, p. 54). No other evidence to support this contention was provided.

The programme came to greater public attention in April 2010 when,

after it gained the support of Cabinet and funding through the Western Australia Royalties for Regions programme, the Ministers for Agriculture and Environment jointly announced the barrier fence upgrades and extensions, along with increased effort to bait and kill Dingoes and feral Dogs (Redman & Faragher 2010). The largest proposals within this programme are the construction of 150 km of new barrier fence between two existing sections known as the 'Yilgarn Gap' and some 650 km known as the 'Esperance Extension' that would extend the fence around the southern edge of the Great Western Woodlands (Redman & Faragher 2010; Grylls & Baston 2013) (Figure 1).

Work began around 2010 on upgrades to the existing fence, with some 820 km upgraded to 'wild dog standard', a phrase used to describe improved effectiveness as a barrier against wildlife and feral dogs, and achieved primarily through the addition of mesh 'lap' wires where the fence meets the ground (DAFWA 2013a; Grylls & Baston 2013). Construction of the 165 km fence to fill the 'Yilgarn Gap' began in May 2014 (Baston & Redman 2014; DAFWA 2013b), with the project reportedly meeting Western Australia's environmental and heritage approval standards (DAFWA 2012a), but without an assessment from the Western Australian Environmental Protection Authority. The final step in this programme is the major fence extension proposed for the Esperance area, which 'aims to complete the physical barrier presented by the SBF (State Barrier Fence) from coast to coast and increase the resilience of vermin control in the associated agricultural areas' (GHD 2012, p. 1).

The joint ministerial announcement of this proposed extension (Redman & Faragher 2010) was made without any comprehensive assessments of its likely ecological impacts or benefits, with the Department of Agriculture not undertaking an internal assessment until 2012 (Invasive Species Program DAFWA 2012). Even 2 years later, the then Department of Environment and Conservation were still 'not conducting any research into the impact and effect of barrier fences as such', even though they recognised their role as providing 'the best advice we can into what the government's proposal is' (Standing Committee on Estimates & Financial Operations 2012, p. 23). Despite this, several assertions have been made in relation to the relative costs and benefits that are not supported by independent studies elsewhere.

For example, the then Minister for Environment stated, in support of the proposed fence, that '... wild dogs caused considerable damage to the environment, preyed on native wildlife and destroyed habitats' (Redman & Faragher 2010). It was not specified how 'habitats were being destroyed' and this claim is contrary to extensive published literature (e.g. Ritchie & Johnson 2009; Letnic *et al.* 2012; Ritchie *et al.* 2012).

Elsewhere, Department of Agriculture staff and farmer proponents have described the barrier fences as 'non-lethal' wildlife management tools (Esperance Express 2013; Read 2013), and this description gained some local currency (e.g. SCNRM 2013). Even discounting the tens of thousands of Emus regularly shot, poisoned or starved along the fence, many native animals, including kangaroos and wallabies, also clearly and obviously suffer and die when caught in the fence (Figure 6).

Political defence of the proposal to extend the State Barrier Fence continues in the face of the environmental problems outlined above, and despite there being no documented objective estimate of the impact on either target or non-target wildlife, or publicly available tests of the impact of the barrier fences on vertebrate fauna. This example from Western Australia corresponds with what is seen by many as a growing trend for governments in Australia to defend their land-use decisions by ignoring, dismissing or contradicting existing robust research on ecological impacts of particular activities (see, e.g. Fitzsimons 2012; Lindenmayer 2013).

Additionally, the extent of damage to agricultural productivity on the edge of the Wheatbelt caused by wildlife is poorly known, with DAFWA scientists lacking survey data and basing their conclusions largely on anecdotal evidence (URS 2007; DAFWA 2012b) that generally originates from the farmers who have been seeking the fence upgrades (Rampling 2011; Wynne 2011; DAFWA 2012a, 2013c, 2014) or from studies that include unconfirmed ben-

Figure 6. Wildlife is regularly caught in the State Barrier Fence. This kangaroo had been trapped for many days when found on the Fence east of Lake Varley. (Photo Frank Rijavec.)

efits such as a presumed reduction in vehicle collisions with wildlife some 30–50 km from the State Barrier Fence (ERA 2009).

The intended placement and design of the Esperance component has become slightly less damaging since it became subject to wider public scrutiny. The initial concept plans were for a continuous fence of 450–490 km (URS 2007, p. 16; DRDL undated), sections of which were well inland of existing farmland and placed approximately 84,000 ha of the Great Western Woodlands into the agricultural zone (calculated using ARC-GIS by A. Keesing, Information Manager, Gondwana Link Ltd). Construction funds were allocated from the Western Australian Government's Royalties for Regions programme and site works appeared imminent, with a 2015 deadline for completion (Redman 2010). Following adverse media coverage (e.g. ABC 2012), including an information programme run by private conservation groups (e.g. CCWA 2012) that focused on environmental impacts, DAFWA commissioned a scoping study to identify the 'least constrained' option for the route of the fence (GHD 2012), with current publicly available options now focused on a longer fence placed largely on farm boundaries (DAFWA 2013d), although this could change to reduce costs and with small 'gaps' in the fence where river valleys are to be crossed. DAFWA has subsequently commissioned flora, fauna and heritage surveys along the preferred route (DAFWA 2013d).

However, the information requested by DAFWA from its consultants (GHD 2012; DAFWA 2013d) focuses on site impacts, particularly the presence of species legally protected under Western Australian or national legislation. Broader considerations, such as disruption of large-scale genetic exchange, benefits of Dingoes for controlling feral predators and adverse impacts from other disrupted ecosystem services (e.g. seed dispersal) have had little consideration.

Need for Public Environmental Review and a process to consider alternatives

In Western Australia, proposals likely to have a large impact on the environment are ordinarily assessed by the Environmental Protection Authority (EPA), a statutory authority responsible for providing advice to the Minister for Environment under the *Environmental Protection Act 1986*. The Environmental Protection Authority applies a Public Environmental Review assessment where the proposal is of regional and/or statewide importance or has several key environmental factors or issues, some of which are complex or strategic (Office of the EPA 2012). The Western Australian Government's programme of proposed upgrades and extensions to the barrier fence meets all or most of these criteria for assessment, and ideally, the Public Environmental Review process would have been applied to the entire programme of State Barrier Fence upgrades and extensions so that cumulative impacts could be assessed.

Despite the fence upgrades being underway since 2010, with detailed planning for the extensions underway since 2012, as of August 2014, the works and planned extensions had not been referred by DAFWA to the Environmental Protection Authority for formal environmental assessment, with the only formal referral for the Esperance Extension coming from the private conservation sector (CCWA 2013). From currently available documentation, it seems DAFWA is intending to submit a proposal for Environmental Protection Authority assessment following site-specific biological surveys on a single preferred fence alignment (DAFWA 2013d). Hence, it is likely that if a proposal is formally presented for statutory assessment, whether under the Western Australia legislative framework or nationally, the proposal will under state the impact on ecological processes across the landscape in which the fence will be constructed and maintained. It is therefore our view that an EPA assessment is needed and this should include the entire fence rather than sections. Considering the shortcomings outlined above a full benefit–cost analysis that considers alternative management approaches is also required and is likely to lead to better outcomes that are more acceptable to a broader range of stakeholders.

Implications of inadequate consideration of environmental impacts

Since 1902 when the State Barrier Fence was first established, our understanding of what species and ecosystems need for their long-term persistence has improved, along with a transformation in our understanding and appreciation of the biological richness of south-western Australia. This rapid and continuing increase of knowledge, combined with the area's recent environmentally destructive history, has led to international recognition of the area as a global Biodiversity Hotspot '... where exceptional concentrations of endemic species are undergoing exceptional loss of habitat' (Myers *et al.* 2000, p. 853). This recognition reflects the area's botanical richness (Myers *et al.* 2000; Hopper & Gioia 2004) and massive habitat loss (Bradshaw 2012). As such, many bird and mammal species that have mostly disappeared from smaller woodland and mallee remnants elsewhere in southern Australia are still relatively common in the area adjoining the proposed fence extensions, the Great Western Woodlands (Recher 2008; Bradby *et al.* 2011), which is large and intact enough to be the world's largest remaining temperate woodland (Wat-

son *et al.* 2008; DEC 2010; Prober *et al.* 2012).

The intensely localised occurrence of many endemic plant species and the lack of comprehensive biological surveys have been long identified as issues of concern with development proposals (Burgman 1988), because it puts endemics at high risk of extinction. This is the case for the proposed Barrier Fence extensions, even if the fence is largely placed around existing farm boundaries. For example, *Eucalyptus misella* is a rare, locally endemic species comprised of only one small population (Malcolm French, 12 March 2014, Eucalypt specialist and author, pers. comm.) that was nearly exterminated when farmland was cleared north-east of Esperance in the 1980s. Many of the few remaining plants were further damaged when the state conservation agency bulldozed and chained fire-breaks adjoining that farmland (observed by K. Bradby and W. O'Sullivan, Nov 2011). This richness and threat is only now starting to be reflected in protective measures, such as the listing as a threatened ecological community under national legislation of the Proteaceae-dominated kwongkan shrublands found throughout much of the botanical sub-province inland of Esperance (Department of the Environment 2014). The route of the proposed fence extensions also crosses suitable intact habitat for nationally threatened fauna species, including the Chuditch (*Dasyurus geoffroii*), Dibbler (*Parantechinus apicalis*), Western Whipbird (*Psophodes nigrogularis*), Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) and Western Ground Parrot (*Pezoporus flaviventris*) (GHD 2012).

The rationale for the upgrades and extensions relies on the assumption that land use on either side of the fence is unlikely to change. The opposite is more likely, and conversion to other uses is already underway, making the establishment of a rigid boundary particularly unwise. For example, many grazing leases in the southern rangelands that adjoin the northern section of the existing fence are not commercially viable, largely due to declining terms of trade, reduced carrying capacity and reductions in palatable perennial shrubs available for stock (Government of Western Australia 2009). Many pastoral leases are now owned and managed for their conservation and cultural values or because they include important mineral resources (e.g. van Etten 2013; Fitzsimons *et al.* 2014); and the need for better landscape-scale planning to guide future land use is increasingly recognised (Safstrom & Waddell 2013).

The Western Australian Government is already proposing changes in tenure arrangements to support diversification of leasehold land, including for conservation use (WA Department of Lands 2013). This could support the closure of water sources on conservation and other rangeland properties that, while needing to be done carefully (Wallach & O'Neill 2009), might be effective in reducing the seasonal fluctuation of Emu densities. On the agricultural side, Western Australia's eastern and southern Wheatbelt is becoming increasingly marginal, due to both climatic and economic changes (Van Gool & Vernon 2005), with escalating debt lowering farm viability (Wheatbelt NRM 2013). Some areas in the Wheatbelt are already being converted to other uses, particularly carbon sequestration (e.g. Carbon Conscious 2013).

Much of the agricultural land adjacent to the proposed Esperance extension was allocated to agriculture from the late 1960s to the early 1980s, in a poorly planned government programme that had minimal regard for agricultural viability or environmental impacts (Jasper 1984). That programme finally collapsed in 1983, leaving a legacy of marginal farms (Jasper 1984). Various soil and agricultural studies have subsequently documented serious concerns about the long-term viability of specific areas (e.g. Scholz & Smolinski 1996). Some property owners from allocations in the early 1980s, and adjoining the proposed fence extension, have already received *ex gratia* payments from the Western Australian Government because their soil types have been deemed unsuitable for agriculture or because government clearing controls aimed at reducing salinity were introduced over large areas of this recently allocated land.

Concluding comments

Barrier fencing is a management tool from an era where much wildlife was considered 'vermin' with bounties paid for their destruction. Not only is this an archaic concept, its effectiveness and economic benefits are questionable at best and counterproductive at worst.

The push for a total barrier fence around south-western Australia promotes a future where agriculture is somehow barricaded against the natural flows and rhythms of the Australian continent, with larger Australian wildlife categorised as 'pest species' and dealt with through industry-determined, taxpayer-funded 'invasive species' programmes. Such a retrograde approach to integrating agricultural production and biodiversity values clearly requires rethinking. These issues are problematic for the connectivity conservation programmes emerging across Australia, which generally strive to develop working landscapes where biodiversity conservation and commercial production can coexist. While much is already being achieved through cooperation, for those programmes to be successful, connectivity needs greater recognition in the decision-making of state and national governments on future land use and infrastructure.

In some areas, such as the margins of agriculture in Western Australia, achieving an equitable balance

between the needs of agriculture and the needs of wildlife requires better integrated, more efficient and more humane techniques than government and industry currently propose. The challenge for government is to rise above sectoral lobbying and allocate public funds where they can most effectively achieve outcomes of long-term public good.

While we cannot fully resolve the vexed question of how wildlife persistence can be improved in agricultural areas, the available evidence suggests that barrier fencing is ineffective and has more negative environmental consequences than is generally appreciated. More open-dialogue and evidence-based approaches are needed if equitable and effective coexistence is to be achieved.

In relation to the existing barrier fence and proposals for its extension, considering the large investment of public funds required and the negative effects that such infrastructure is likely to have over a such a large area, a full environmental assessment by the Western Australian Environment Protection Authority, as well as a rigorous cost–benefit analysis that includes the environmental costs, are needed

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