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Risk assessment of the proposed extension to the State Barrier Fence on the Brush Wallaby

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1 INTRODUCTION

1.1 Background

The Department of Agriculture and Food of Western Australia (DAFWA) is seeking environmental approval for the extension of the State Barrier Fence north and east of Esperance, and has been asked by the state Environmental Protection Authority (EPA) to provide information on the potential risk posed to the Brush Wallaby (*Notamacropus (formerly Macropus) irma*) (Jourdan 1837). Potential risks include the effects of population fragmentation and changes in the abundance of predators and competitors due to the construction of the fence.

To meet this request, Bamford Consulting Ecologists (BCE) has been commissioned by DAFWA to conduct a risk assessment based upon a scientific literature review. The objective of the assessment is to provide "Advice on whether the reserves inside the fence could support viable populations, how much movement/genetic variation may be required to maintain viable populations, and any other information that will help the EPA determine the risk that the barrier fence poses to the Brush Wallaby." The identified risk factors may also apply to populations outside the fence.

The assessment draws upon general information on the biology of the species (the main species' study appears to be one carried out by Bamford and Bamford (2002) in Whiteman Park which provides information on population density and home range area), and a review of population genetics as they apply to mammals of about the size of the Brush Wallaby. Some additional information was sourced from scientific papers, technical reports, previous impact assessment reports and databases, including records from the Department of Parks and Wildlife (DPaW; pers. comm.). No fieldwork was conducted as a part of the study but information on vegetation types, reserve sizes and the location of the fence in relation to potential Brush Wallaby habitat was sourced from studies conducted as part of the environmental approval process (Ecoscape 2015).

1.2 Project overview

The State Barrier Fence currently runs for 1190 kilometres (km) starting north of Kalbarri on the coast at Zuytdorp Cliffs to 25km east of Ravensthorpe. A 660km extension of the fence is proposed around the Esperance agricultural zone in order to protect the area from wild dogs, emus and kangaroos (DAFWA 2016). The extension will be constructed from east of Ravensthorpe to east of Esperance and will be aligned between Unallocated Crown Land (UCL) in the north and private agricultural land in the south. When constructed, the area of land inside the fence extension would be approximately 18,000km^2.

Fence construction details are provided in DAFWA (2016) and briefly summarised here. The fence will be constructed of ten-line fabricated wire netting with a height of approximately 1.35m. A single strand of 2.8mm high tensile plain wire will be situated on top of the fabricated netting. Star pickets with a height of 1.8m are placed every 7m with 1.3m high visibility fluorescent orange droppers attached to the fence 7m apart (in-between the star pickets). Lap wire extends 400mm from the base of the fence along the ground under tension to prevent wild dogs and macropods burrowing under the fence. The fence will be located in the middle of a 6m wide cleared area, within a low fuel buffer zone 15-20m in width.

On private land, existing farm fences will be replaced. Three main river systems including the Oldfield, Young and Lort occur along the proposed alignment but will not be fenced, allowing movement of some wallabies (and feral predators) through the fence in these locations. Furthermore, a 3.2km gap will be left on the eastern side between agricultural land and the coast at Cape Arid National Park (DAFWA 2016). To reduce incursions particularly of wild dogs where the fence will be incomplete, baiting on the outside of the fence will be conducted along a 10-20km wide buffer.

2 BIOLOGY, ECOLOGY AND DISTRIBUTION OF THE BRUSH WALLABY

The Brush Wallaby (Brush-tailed or Black-gloved Wallaby; also referred to as the Western Brush Wallaby but the 'Western' is redundant as there is no 'Eastern' Brush Wallaby; Kwoora is the most widely-accepted aboriginal name) is endemic to the south-west of Western Australia and occurs from North of Kalbarri to Cape Arid National Park, east of Esperance. It commonly occurs in dry sclerophyll forest, banksia woodlands and shrublands, typically favouring dense low vegetation that provides dense cover. The breeding season is not well understood, but DPaW (2012) reports that young appear to be born from April – May and emerge from the pouch around October or November. However, Bamford and Bamford (2002) recorded a female with a very small pouch young in February, a female with a large and semi-independent young (still suckling) in June and a female with a fully-furred pouch young in September. This suggests an extended breeding season. Remote camera monitoring surveys conducted for the Gondwana Link Ltd. project suggest that there could be more than one breeding season per year, at least in some years (Gilfillan and Harvey 2014).

Christensen (1983) reports that Brush Wallaby numbers declined in the 1970s due to fox predation. Although adult Brush Wallabies, which weigh up to nine kilograms (kg), may be too large to fall prey to the Fox, young wallabies lie within the Critical Weight Range identified by Burbidge and McKenzie (1989). There are anecdotal reports that the species increases in abundance following Fox control.

Abundance of Brush Wallabies may therefore reflect predation pressure, but in Whiteman Park (with Fox control) the population density ranged from 0.068 to 0.22 wallabies/ha, with an average density of 0.16/ha.

Brush Wallabies are solitary, nocturnal but tending to be more active just after sunset and just before sunrise, and appear to be very tolerant of noise, light and movement, with animals spending both daylight hours and the hours of darkness close to major sources of potential disturbance. Recently-burnt areas, at least up to two years post-fire, are favoured for foraging but are not essential, whereas access to dense vegetation for shelter. The Whiteman Park study found that males have large home ranges, up to 9.9ha in a night and 69.2ha during a year, and which appear to overlap with several females (up to 5.3ha in a night and 32.5ha during a year (Bamford and Bamford 2002). Male Brush Wallabies are reported by wildlife carers to be very intolerant of each other, so male home ranges may not overlap. The Brush Wallaby appears to be the only macropod that is not sexually dimorphic, which further suggests a largely solitary species in which individuals may rarely interact directly.

Brush Wallabies tend to rely more on moisture derived from plants than from free-water sources (Wann and Bell 1997), and the Whiteman Park study that radio-tracked eight animals for a year never recorded individuals visiting nearby water points.

The Department of Parks and Wildlife (DPaW) classes the species as Priority 4, which means that the population had declined and requires monitoring, but it not currently endangered. The proposed fence extension is situated in the eastern part of the species' current distribution.

A search of DPaW's Naturemap identified five records in the project area (Figure 1). One sighting was recorded outside the proposed fence, west of Lake Gilmour near the Lake King Norseman Road. The species was also recorded at East Naemup Nature Reserve (located approximately 40km west of the barrier fence and five km west of Munglinup). Other records include: one near the south coast (approximately 15km south of Munglinup) and two within five km of the Esperance town site (DPaW 2016). The Atlas of Living Australia (ALA) database contains two records, the first in a similar location to DPaW northern record (west of Lake Gilmour) and a second approximately five km north of Esperance near the Leda Nature Reserve (ALA 2016) (Figure 1).

Surveys conducted along the proposed fence alignment by Ecoscape (2015) recorded the species at three different locations in mallee shrubland over mixed shrubs and mallee woodland over mixed shrubs (Figure 1). Duncan *et al.* (2006) also recorded the Brush Wallaby in recently burnt habitat near Lake Metcalf within the Honman Ridge Bremer District, located approximately 65km north-west of the northern boundary of the fence.

Since 2013, DPaW has employed motion-sensitive cameras to monitor feral predator populations (i.e. foxes and cats) in the Cape Arid and Fitzgerald River National Parks. The cameras have also recorded numerous Brush Wallabies, suggesting considerable populations are present in these areas (Figure 1). DPaW personnel report that the species occurs throughout the fenced and unfenced areas and across to the Nuytsland Nature Reserve (located approximately 300km to the east (DPaW, pers comm, 2016).

Note that while there are almost no records outside the proposed fence extension, this is likely to be an artefact of where observations have been made, as areas outside the fence are largely inaccessible.

3 DISCUSSION OF POTENTIAL IMPACTS TO BRUSH WALLABY POPULATIONS

The potential impacts to the Brush Wallaby from the barrier fence have been highlighted in various reports (GHD 2012; Ecoscape 2015; DAFWA 2016). Key impacts include:

1. Population fragmentation and isolation leading to genetic isolation;
2. Changes to predator and competitor abundance; and
3. Fire and fire management strategies.

These impacts do not exist in isolation, but inter-action can occur. For example, a small population may vulnerable not only to effects of genetic isolation, but may be more vulnerable to predation irrespective of a change in predator abundance.

3.1 Genetic isolation and Minimum Viable Population

The existing farm boundary fences currently present a soft barrier to the Brush Wallaby and are likely to provide many opportunities for animals to pass through the fence (i.e. from washouts or damaged fences). There are also sections of the proposed barrier fence extension that are currently unfenced. Therefore, Brush Wallabies may be adversely affected as a result of the barrier extension as animals are unlikely to be able to pass through or over the fence. During capture of Brush Wallabies in Whiteman Park, one animal did leap over the capture net (about 1.2m), this is slightly lower than the top wire of the barrier fence (about 1.35m). Except for intended gaps in the extended barrier fence at the three main river systems (Oldfield, Young and Lort Rivers), and in the east (near the coast at Cape Arid National Park) (Figure 1), the fence will effectively divide Wallaby populations; although perhaps under pressure, Brush Wallabies may rarely be able to clear the barrier fence. Populations isolated on either side of the fence are potentially at risk from local extinction and in-breeding; Epps *et al*. (2005) found that Big-horn Sheep in North America suffered from population fragmentation and resultant in-breeding due to the construction of a highway through a population.

In the long term, Brush Wallaby populations that are not refreshed by new migrants may become genetically in-bred. This could occur either side of the barrier fence where the fence passes through a restricted area of suitable habitat. Areas of suitable habitat are restricted inside the fence due to clearing for agriculture and furthermore, Brush Wallabies rarely cross open ground. In Whiteman Park wallabies almost never left cover (Bamford and Bamford 2002), and therefore in agricultural areas movement between remnants is likely only to occur if there are corridors of dense vegetation alongside roads. Wallaby populations in small remnants in agricultural areas are thus likely to be isolated with little if any genetic exchange unless some connectivity exists. The fence may also separate animals outside the fence from pasture inside the fence, although in Whiteman Park Brush Wallabies only occasionally left bushland to graze even where pasture was available (Bamford and Bamford 2002).

Wallabies outside the fence may also be at some risk from population fragmentation as suitable habitat is not continuous and the fence passes through the edge of the species' range, so populations outside the fence may already be small, naturally fragmented and at low densities. However, native vegetation outside the fence is intact and movement between populations is likely to occur. Fragmentation risk is therefore greatest for small and substantially isolated populations inside the fence.

The concern with isolation is that in-breeding can lead to loss of genetic diversity and lowered breeding success Mills and Allendorf (1996) hypothesize that somewhere between one and ten migrants per generation is sufficient to maintain genetic diversity in substantially isolated mammal populations. The generation time of Brush Wallabies is probably less than 10 years (Bamford and Bamford 2002) while that of larger macropods is more than 10 years (Russell 1989).

There is currently a lack of data for Brush Wallabies in terms of population dynamics, numbers of animals and area required to support a minimum viable population specific for the Esperance region (or indeed any region). Although minimum viable population (MVP) size for fauna in general has been debated extensively in the literature, there is still no real agreement as to what constitutes a minimum viable population (Saunders *et al.* 1990). Frankel and Soule (1981) suggest a MVP for mammals of 500, but this is considered only a guideline and the minimum viable population for a species can vary with aspects of its biology (Usher 1987). Belovsky (1987) developed a theoretical model for MVP size but Short and Turner (1991) suggest this should be treated with caution. They calculated a MVP for the Euro *Macropus robustus* on Barrow Island of 200-300 animals, but estimated that the actual population was around 1,800. The population of Euros has low genetic variability indicating that in-breeding has occurred, but it appears to be viable. Barrow Island Euros have existed in isolation for some 15,000 years and are over twice the weight of the Brush Wallaby.

Brush Wallabies at Whiteman Park were found to occur at an overall density of 0.16 wallabies/ha, which equates to a population of 160 animals in the 1000ha conservation area of the park (Bamford and Bamford 2002), although there are additional animals in adjacent areas of the park. Even with these additional animals, the population is probably in the order of 250 and has persisted more or less in isolation for over 50 years. The value of 250 is within the MVP range proposed for the Barrow Island Euro by Short and Turner (1991). A population of 250 individuals at a density of 0.16 wallabies/ha would require approximately 1500ha to be viable, although it is not known if the population density in Whiteman Park would also occur in the barrier fence project area.

In order to determine the possible effect of habitat fragmentation by the extension of the barrier fence, an assessment was conducted of the areas of remnant vegetation situated inside the fence. Vegetation data was sourced from surveys carried out by Ecoscape (2015) and Beard *et al.* (2013).

Fifteen areas were identified, comprising DPaW managed land and other land (e.g. freehold, Shire, etc) (Figure 1, Table 1). Note this is not an exhaustive list of all the remnants in the agricultural zone (such an analysis is outside the scope of this study), but is a selection to illustrate the potential impact on a range of areas and focusses on areas close to the fence and thus where impacts are most likely to occur. Brush Wallaby populations that occur along the south coast (where vegetation is more or less continuous (Figure 1)) are considered to be at less risk from the fence, as are animals in areas of vegetation connected to a river system (i.e. Oldfield, Young and Lort), as gaps in the fence are likely to facilitate the movement of migrants in and out of these areas. The list of remnants also

does not include the many small fragments of native vegetation that are already largely isolated within the agricultural landscape. If present, Brush Wallaby populations in these small fragments are probably already under pressure from isolation. Exceptions are where small fragments lie close to the route of the barrier fence as in such areas there may be wallabies that are part of larger populations that live in the extensive uncleared areas outside the fence alignment.

The 15 areas ranged in size from 400ha to c.a. 38,200ha, with an average size of 7,405ha. Three of the sites identified were below the 1500ha minimum. Based on the vegetation present, Mallee woodland and shrubland (Table 1), the majority of the sites have the potential to support wallabies. The analysis provides some basic indication (in terms of land area) that the majority of the large remnants inside the fence are large enough to support viable populations of wallabies. Large remnants make up the majority of remnant native vegetation inside the fence (Figure 1), but there are small remnants that would become isolated by construction of the fence and that might be incapable of supporting Brush Wallabies in the long term. Therefore, loss of Brush Wallabies due to isolation could occur from small remnants that are cut off by the fence and have limited connectivity with other remnants inside the fence, but regionally there are sufficient large remnants inside the fence to maintain viable populations. The persistence of wallabies in small remnants may be influenced by the distance to large remnants and/or to gaps in the fence, which will affect the potential for the movement of occasional individuals between remnants.

In-breeding effects on small, isolated populations may take several generations to become apparent, but there may be more rapid impacts from environmental factors such as increased predation and fire, and these are discussed below.

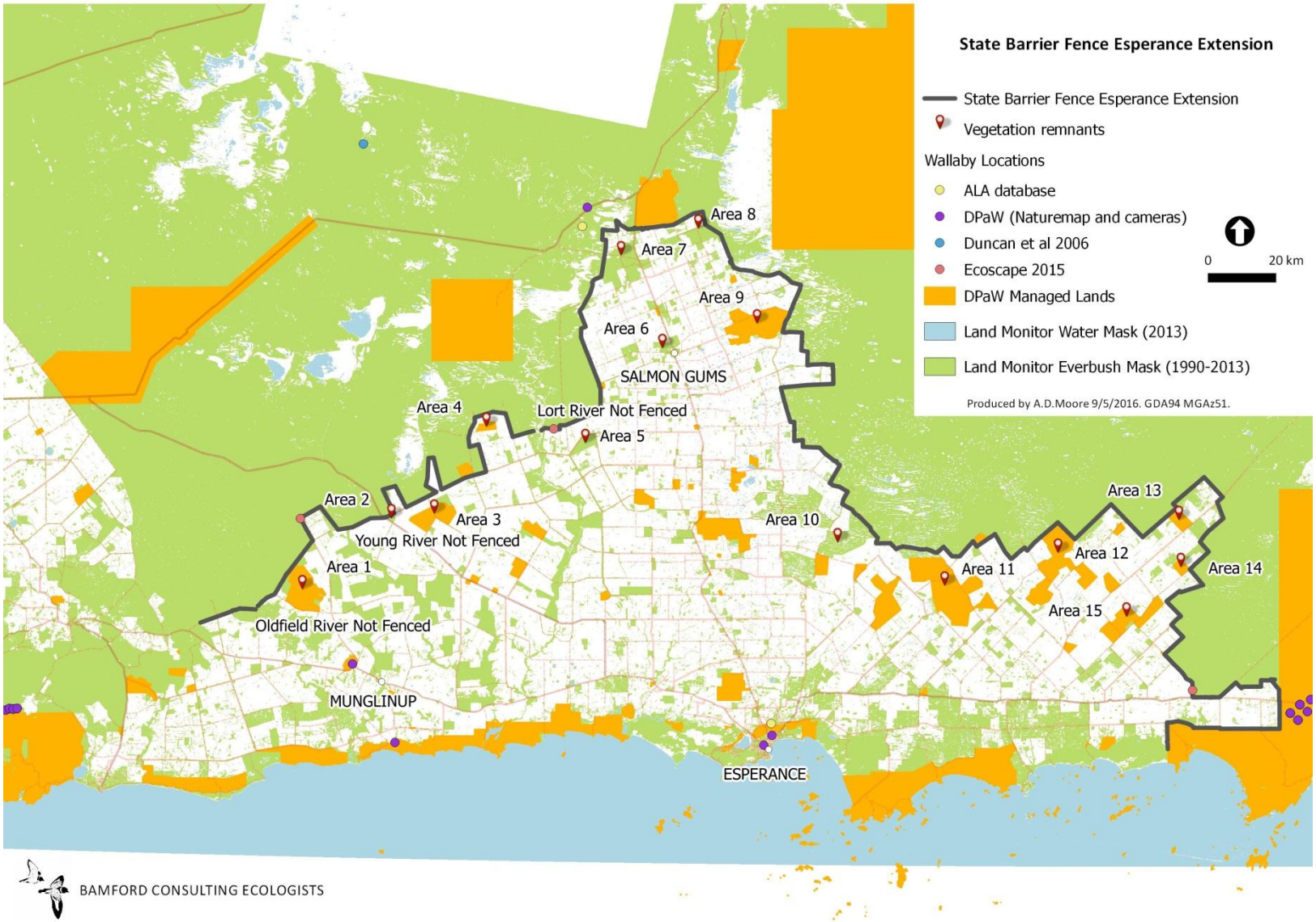

Figure 1. Regional Brush Wallaby records and areas of remnant native vegetation.

Table 1. Description of remnant native vegetation located inside the proposed fence extension and area. Based on Ecoscape (2015) and Beard *et al.* (2013).

Native vegetation remnants	Tenure	Vegetation type	Area (ha)
Area 1- Cheadanup Nature Reserve, R 31754	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Ecoscape (2015): **CqAp** – *Calothamnus quadrifidus*, *Acacia assimilis* subsp. *atroviridis* and *Grevillea teretifolia* mid open shrubland over *Acacia pinguiculosa* subsp. *teretifolia*, *Cryptandra graniticola* and *Lepidosperma rigidulum* low shrubland/sedgeland. **EpBmMs** – *Eucalyptus pleurocarpa*, *E. phaenophylla* and *E. incrassata* mid open mallee shrubland over *Beaufortia micrantha* var. *micrantha*, *Melaleuca rigidifolia* and *M. hamata* mid open shrubland over *Mesomelaena stygia* subsp. *stygia*, *Lysinema pentapetalum* and *Lepidosperma* spp. low open sedgeland/shrubland. **EpEa** – *Eucalyptus platypus* subsp. *platypus*, *E. flocktoniae* subsp. *flocktoniae* and *E. dielsii* low open woodland over *Exocarpos aphyllus*, *Gastrolobium musaceum* and *Daviesia argillacea* mid open shrubland. **EsBpLt** – *Eucalyptus sporadica* and *E. clivicola* mid mallee woodland/woodland over *Baeckea pachyphylla*, *Melaleuca eurystoma* and *M. hamata* mid open shrubland over *Lepidosperma tuberculatum* and *Tetraria* sp. Mt Madden (C.D. Turley 40 BP/897) mid open sedgeland.	6828
Area 2 – Cascades Road, east of Young River	Unknown*	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Ecoscape (2015): **EeMsGa -** *Eucalyptus eremophila*, *E. flocktoniae* and *E. scyphocalyx* low woodland/mallee woodland over *Melaleuca societatis*, *M. sapientes* and *M. teuthidoides* mid shrubland over *Gahnia ancistrophylla*, *Spyridium minutum* and *Comesperma spinosum* low open sedgeland/shrubland.	400
Area 3 - Griffiths Nature Reserve, R 30583	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Not surveyed by Ecoscape (2015).	5415
Area 4 – Nature Reserve, R 43949	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Woodland-other - Wheatbelt; York gum, salmon gum etc. *Eucalyptus loxophleba*, *E. salmonophloia*. Goldfields; gimlet, redwood etc. *E. salubris, E. oleosa*. Riverine; rivergum *E. camaldulensis* (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	717
Area 5 – Williams Road, East of Lort River	Unknown*	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Woodland-other - Wheatbelt; York gum, salmon gum etc. *Eucalyptus loxophleba*, *E. salmonophloia*. Goldfields; gimlet, redwood etc. *E. salubris, E. oleosa*. Riverine; rivergum *E. camaldulensis* (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	2700
Area 6 – Salmon Gums	Unknown*	Woodland / Mallee (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	c.a. 3000
Area 7 - West of Coolgardie – Esperance	Unknown*	Woodland / Mallee (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	c.a. 12000

Native vegetation remnants	Tenure	Vegetation type	Area (ha)
Highway			
Area 8 – Fagan Road, East of Coolgardie – Esperance Highway	Unknown*	Woodland / Mallee (Beard *et al.* 2013). Woodland-other - Wheatbelt; York gum, salmon gum etc. *Eucalyptus loxophleba*, *E. salmonophloia*. Goldfields; gimlet, redwood etc. *E. salubris, E. oleosa*. Riverine; rivergum *E. camaldulensis* (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	c.a. 6150
Area 9 - Salmon Gums Nature Reserve, R 33113	DPaW	Woodland / Mallee (Beard *et al.* 2013). Ecoscape (2015): **DhCc** – *Duboisia hopwoodii* and *Rhagodia preissii* mid sparse shrubland over *Commersonia craurophylla*, *Acacia glaucissima* and *Glischrocaryon aureum* low open shrubland/ herbland. **EcCc** – *Eucalyptus conglobata* low open mallee woodland over *Commersonia craurophylla*, *Acaciaglaucissima* and *Glischrocaryon aureum* low open shrubland/herbland. **EeMlOm** – *Eucalyptus eremophila*, *E. leptocalyx* and *E. valens* mid open woodland over *Melaleuca linguiformis*, *M. thyoides* and *Alyxia buxifolia* mid open shrubland over *Olearia muelleri*, *Scaevola spinescens* and *Waitzia suaveolens* var. *flava* low open shrubland/herbland. **EeMsGa** – *Eucalyptus eremophila*, *E. flocktoniae* and *E. scyphocalyx* low woodland/ mallee woodland over *Melaleuca societatis*, *M. sapientes* and *M. teuthidoides* mid shrubland over *Gahnia ancistrophylla*, *Spyridium minutum* and *Comesperma spinosum* low open sedgeland/shrubland. **MaTs** – *Melaleuca acuminata* subsp. *acuminata*, *M. thyoides* and *M. lanceolata* tall shrubland over *Triodia scariosa*, *Bossiaea leptacantha* and *Westringia rigida* low open hummock grassland/shrubland. **Tspp** – *Tecticornia* spp. and *Maireana oppositifolia* low open samphire shrubland/chenopod shrubland.	c.a. 14780
Area 10 – Mount Ridley Nature Reserve, R 27386 and other land	DPaW, Unknown*	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	1417 + c.a. 36800[+]
Area 11 – Kau Nature Reserve, R 32777	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Woodland-other - Wheatbelt; York gum, salmon gum etc. *Eucalyptus loxophleba*, *E. salmonophloia*. Goldfields; gimlet, redwood etc. *E. salubris, E. oleosa*. Riverine; rivergum *E. camaldulensis* (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	8544
Area 12 - Beaumont Nature Reserve, R 32783	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Thicket - Wattle, casuarina and teatree acacia-allocasuarina-melaleuca alliance (Beard *et al.* 2013). Ecoscape (2015): **EdDiMa** – *Eucalyptus dielsii*, *E. ?calycogona* and *E. uncinata* mid woodland/mallee woodland over *Daviesia incrassata* subsp. *incrassata*, *Dodonaea stenozyga* and *Melaleuca teuthidoides* mid open shrubland over *Microcybe albiflora*, *Spyridium minutum* and *Westringia rigida* low sparse shrubland.	7078

Native vegetation remnants	Tenure	Vegetation type	Area (ha)
		EgAs – *Eucalyptus grossa*, *Melaleuca uncinata* and *Calothamnus quadrifidus* subsp. *quadrifidus* mid shrubland over *Acacia sulcata* var. *platyphylla*, *Lepidosperma drummondii* and *Cryptandra minutifolia* subsp. *brevistyla* low open shrubland/sedgeland. Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Ecoscape (2015): **EuGpBi** – *Eucalyptus uncinata* and *E. leptocalyx* mid open mallee shrubland over *Grevillea plurijuga* subsp. *plurijuga*, *Melaleuca hamata* and *M. societatis* mid open shrubland over *Boronia inornata* subsp. *leptophylla*, *Pultenaea purpurea* and *Hibbertia psilocarpa* low open shrubland. **EuMtDl** – *Eucalyptus uncinata* and *E. tumida* mid sparse mallee shrubland over *Melaleuca teuthidoides*, *M. rigidifolia* and *M. hamata* mid shrubland over *Daviesia lancifolia*, *Pultenaea elachista* and *Microcybe albiflora* low open shrubland. **EuMtPe** – *Eucalyptus uncinata*, *E. conglobata* and *E. indurata* mid open mallee woodland over *Melaleuca teuthidoides*, *Daviesia incrassata* subsp. *incrassata* and *M. calycina* mid open shrubland over *Pultenaea elachista*, *Spyridium minutum* low sparse shrubland. **MbAj** – *Melaleuca brevifolia*, *M. subalaris* and *M. thyoides* mid open shrubland over *Austrostipa juncifolia* and *Tecticornia* spp. mid sparse grassland/samphire shrubland.	
Area 13 – Clyde Hill Nature Reserve, R 38545	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Salt lake, lagoon, clay pan (Beard *et al.* 2013). Ecoscape (2015): **EgMtBi** – *Eucalyptus gracilis* and *E.* sp. low open woodland over *Melaleuca teuthidoides* mid sparse shrubland over *Boronia inornata* subsp. *leptophylla*, *Westringia rigida* and *Acacia merrallii* low open shrubland. **ElMbBi** – *Eucalyptus luculenta* and *E. eremophila* low sparse mallee shrubland over *Melaleuca bromelioides* mid open shrubland over *Boronia inornata* subsp. *leptophylla* and *Microcybe multiflora* subsp. *baccharoides* low sparse shrubland. **ElMsAs** – *Eucalyptus luculenta*, *E. uncinata* and *E. eremophila* mid open mallee woodland over *Melaleuca societatis*, *Daviesia benthamii* subsp. *acanthoclona* and *M. hamata* mid open shrubland over *Acacia sorophylla*, *Pultenaea purpurea* and *Boronia inornata* subsp. *leptophylla* low sparse shrubland.	1669
Area 14 - Niblick Nature Reserve, R 38544	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	838
Area 15 - Muntz Nature Reserve, R 31799 and Neredup Nature Reserve, R 32784	DPaW	Mallee - Eucalypt shrubland *Eucalyptus eremophila*, *E. redunca*, E. spp. (Beard *et al.* 2013). Mallee-heath - Mixed heath with scattered mallee e.g. tallerack *Eucalyptus tetragona* (Beard *et al.* 2013). Salt lake, lagoon, clay pan (Beard *et al.* 2013). Not surveyed by Ecoscape (2015)	2750

*Unknown: land could be either Freehold, Crown or Shire land.

[+]This area includes salt lakes and small areas of open water.

3.2 Changes to predator and competitor abundance

Changes to predator and competitor abundance are likely to occur due to the proposed barrier fence and may result in positive and/or negative outcomes for different species. This includes the effect of feral predator species, such as the Fox and Cat, and introduced and native herbivores including Rabbits and kangaroos. The fence is unlikely to form a barrier for the Fox or Cat (fence is 1.35m high and with a mesh size large enough for them to pass through), but can be used as a focus for baiting programmes.

Several studies suggest that the Dingo (including wild dog and hybrids) plays an important role in reducing Fox numbers (Glen *et al.* 2007; Letnic and Koch 2010), and also lowers the density of kangaroos (Pople *et al.* 2000). However, DAFWA (2016) reports that as a result of sustained wild dog management in the agricultural area, wild dogs are probably not at a sufficient density to regulate Emus, kangaroos, Cats or Foxes. Therefore the abundance of the Fox inside the fence has probably already responded (increased) due to the absence of the Dingo/wild dog. The overall abundance of the Fox may thus not alter either side of the fence, but Foxes (and Cats) are attracted to disturbance and tracks (Graham *et al.* 2012), and therefore there may be a localised concentration of predators along the fence.

The consequences of such changes in abundance and distribution for Brush Wallabies are uncertain. While the species co-exists with high densities of Grey Kangaroos in Whiteman Park, probably because the wallaby is a browser and the kangaroo a grazer (Bamford and Bamford 2002), an increase in the abundance of Foxes is a concern. This would especially be the case for small, isolated wallaby populations located within the fenced agricultural zone. There could also be an increase in the concentration of predators outside and along the fence (due to predators being attracted by disturbance and ready access) which could increase predation rates upon juvenile wallabies. Predation pressure would also increase in those areas where the fence passes through previously unfenced areas, as the fence and associated tracks would provide ready access for predators. Thus, ongoing baiting with sodium fluoroacetate (1080) in a buffer zone of up to 20km along the fence, conducted by a number of groups assisted by DAFWA, is highly recommended to reduce predation pressure.

Chaining native vegetation close to the fence to reduce fuel loads may create foraging habitat for wallabies, but could also expose the species to increased predation by attracting them into areas that do not provide shelter. They could also be more vulnerable to being trapped against the fence by predators. Similarly gaps located in the fence may facilitate the movement of wallabies but may also act as a funnel for predators. On a much smaller scale, this has been demonstrated with fauna underpasses established beneath major roads (Harris *et al.* 2010).

3.3 Fire

Studies at Whiteman Park found that fire is beneficial to the species in creating favoured foraging areas, but unburnt areas appear to provide adequate food and are essential for shelter (Bamford and Bamford 2002). During a wildfire, the fence may act as a barrier and restrict the movement of wallabies to vacate the area. In this situation occurs to a small and isolated population, there is the potential for local extinction.

Strategies employed to reduce the risk of fire, such as chaining vegetation close to the fence, may provide some foraging value for wallabies but could also lead to an increase in predation from feral predators. It is expected that improved access along the fence and the low fuel buffer zone will reduce the likelihood of large wildfire events, which could benefit the Brush Wallaby. A programme that aimed to create a mosaic of fire ages either side of the fence, perhaps using the fence as a control line, would probably favour the Brush Wallaby.

4 CONCLUSIONS AND RECOMMENDATIONS

DAFWA is seeking environmental approval for the extension of the State Barrier Fence and has been asked by the EPA to provide further information on the potential risk posed to the Brush Wallaby. BCE has conducted a desktop literature review and assessment of the risks that the barrier fence poses to the species. The species is definitely present throughout the project area and the key potential impacts are: population fragmentation and isolation leading to in-breeding, changes to predator abundance and fire. Conclusions with respect to each of these processes are summarised below.

Population fragmentation, isolation and in-breeding

The effects of in-breeding are uncertain and the minimum viable population for the Brush Wallaby may be around 250. Based on the population density found at Whiteman Park, this suggests areas of suitable habitat need to exceed 1500ha to maintain viable populations in the long-term. There are many large areas of remnant native vegetation inside the fence that meet this criterion, but populations in small remnants that will be cut off by the fence could become unviable. This would not affect the persistence of the species inside the fence but could lead to local extinction in some small remnants close to the fence. However, movements of individuals between remnants only need to be infrequent to ensure adverse effects of in-breeding in small populations are avoided. Local extinction inside the fence would be most likely in the most isolated (i.e. with no internal connectivity) remnants of native vegetation. Outside the fence, native vegetation is more or less continuous and while not all is core habitat for the Brush Wallaby, the species is sufficiently mobile that genetic mixing outside the fence is likely to occur.

Changes to predator and competitor abundance

The Brush Wallaby is primarily a browser and is thus unlikely to be affected by changes in the abundance of other herbivores such as the Rabbit and Western Grey Kangaroo. An increase in the abundance of the Fox either side of the fence is more of a concern; this could occur inside the fence due to the exclusion of the Dingo, and outside the fence due to movement of Foxes towards the agricultural zone (due to Foxes being attracted to disturbance and tracks Graham *et al.* (2012)). Small, isolated populations of the Brush Wallaby in remnants alongside and inside the fence would be most vulnerable to predation impacts. There may also be an increase in predation pressure at the gap in the fence. Ongoing baiting with sodium fluoroacetate (1080) in a buffer zone of up to 20km along the fence is proposed by DAFWA and is highly recommended.

Fire

Fire is beneficial to the species in creating a mosaic of fire ages that provide food and shelter (Bamford and Bamford 2002). During a wildfire, the fence may act as a barrier and restrict the movement of wallabies. If this situation occurs to a small and isolated population, there is the potential for mortality and local extinction. Chaining vegetation close to the fence may provide some foraging value for wallabies but could also lead to an increase in predation from feral predators, as discussed above. It is expected that improved access along the fence and the low fuel buffer zone will reduce the likelihood of large wildfire events, which could benefit the Brush Wallaby.

Management

The major concern for the Brush Wallaby with respect to the extension of the state Barrier Fence in the Esperance region is with populations in small, isolated remnants (<1500ha but especially remnants <c. 500ha) close to the fence where Fox predation may increase and where the probability of immigration is low. Such small populations in remnants against the fence could also be more vulnerable to mortality during fire. The greatest risk to these populations would be from local extinction due to predation or fire impacts, with a long-term risk of in-breeding. Predator management close to the fence, especially where there are small remnants of native vegetation inside the fence, and at gap locations, is important to maintain wallaby populations. Roadside vegetation rehabilitation and management would improve population connectivity between remnants inside the fence. Any fire management should aim to create a mosaic of ages and could use the fence as a control line.

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