Dampier Peninsula Bilby Offset Project Threat Management Plan

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GOVERNMENT OF WESTERN AUSTRALIA

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Summary

Key threats to wild bilby populations in the north of Australia, include introduced predators (cats and foxes), changed and inappropriate fire regimes, the interaction between fire and introduced predators, land clearing, and grazing by domestic and unmanaged livestock. This plan identifies and assesses threats to bilby populations on the Dampier Peninsula, and analyses the performance and efficiency of management actions.

The highest threat assessed for wild bilby populations on the Dampier Peninsula is the interaction of fire and introduced predators. The management action with the least benefit is managing introduced herbivores and the management action with the most efficiency and value for effort is localised fire management combined with concurrent localised introduced predator management (Table 2). Although this is the most efficient technique providing the greatest reduction in threat, it is unfortunately unavailable to the present offset project as predator management is not permitted under the offset conditions. Therefore, the available management actions that are within the scope of this project and within budget include:

1. Fire management:
   a) Establishing a suitable firebreak surrounding managed populations to prevent large wildfires destroying vegetation structure and food resources and allowing easy predator access within managed populations;
   b) Implementing patch mosaic burning to create fire age heterogeneity, increasing habitat and resource diversity for bilbies;
   c) Some patch burns conducted in late spring or early summer to improve *Yakirra* production.
2. Livestock management:
   a) Negotiating to close artificial water points in the vicinity of managed populations.

Management and monitoring will be implemented at two to three managed, and two to three control populations. Traditional Owner ranger groups will be involved in monitoring, and provide on-ground operations for all management works. Training will be provided as part of the partnership in this project. Outcomes of this project will improve the effect and efficiency of the management of threats by government, industry and natural resource management agencies to ensure the persistence of bilby populations in the wild on the Dampier Peninsula.

1 Introduction

The Commonwealth EPBC approval (*EPBC 2013/6984*) of the Cape Leveque Road upgrade (SLK 25-102.6), Shire of Broome, Western Australia stipulated that a threat management program must be developed for the greater bilby (*Macrotis lagotis*) on the Dampier Peninsula. The approval directed that the plan "*must address either introduced predators, fire regimes or grazing pressure or a combination of these threats at high priority sites for the Greater Bilby*".

The Native Vegetation Clearing Permit approval (CPS 6078/1) issued by the Western Australian Environmental Protection Agency (EPA) further directed that the actions must "*establish or maintain native vegetation on the Dampier Peninsula to address threats to an identified population(s) of Greater Bilby*".

Although the EPBC conditions enabled actions that included management of introduced predators, the EPA altered the condition and specifically limited actions to those associated with the establishment or maintenance of native vegetation to the benefit of the bilby.

A number of key threats to wild bilby populations have been identified in the north of Australia, with the most important being introduced predators (cats and foxes), changed and inappropriate fire regimes, the interaction between fire and introduced predators, land clearing, and grazing by domestic, feral and unmanaged livestock (Bradley *et al.* 2015; Cramer *et al.* 2017). Studies have shown evidence of a negative relationship between these threats and bilby occurrence, as well as models indicating a positive effect on bilby populations if these threats are managed (Southgate and Carthew 2006; Southgate *et al.* 2007b; Southgate and Carthew 2007; Southgate *et al.* 2007a; Southgate 2014).

The purpose of this plan is to identify and assess threats to bilby populations on the Dampier Peninsula, and analyse the performance and efficiency of management actions. This plan is valid for wild bilby populations on the Dampier Peninsula. The Dampier Peninsula area in which management actions may occur under this project is defined in Figure 1.

Figure 1. Dampier Peninsula Bilby Offset Project boundary.

2 Threats present on the Dampier Peninsula

2.1 Introduced Predators

Both the feral cat (*Felis catus*) and fox (*Vulpes vulpes*) are major predators of bilbies (Southgate 1990; McKenzie *et al.* 2007; Woinarski *et al.* 2014; Bradley *et al.* 2015) and both occur on the Dampier Peninsula.

Feral cats are widespread and common across the Dampier Peninsula (FeralScan 2019; NatureMap 2019; pers comm Tradition Owner Ranger Groups). Cats prey on bilbies, however, wherever wild bilby populations exist, cats are present. This means that bilby populations can tolerate a certain threshold of cat activity or abundance. Cats likely switch to preying on bilbies during periods when easier prey items become scarce, or during times when cat densities are high (Woinarski *et al.* 2014), or when attracted by fire (McGregor *et al.* 2016). Juvenile bilbies make easier prey and are likely targeted in preference to large adults resulting in decreased or negligible recruitment.

Foxes can exterminate bilby populations and are hypothesized to be the major cause of the disappearance of bilbies in the southern half of their former range (Woinarski *et al.* 2014; Bradley *et al.* 2015). Fox presence is negatively correlated with bilby presence (Southgate 1990). Foxes exist and have been recorded across the Dampier Peninsula (FeralScan 2019; NatureMap 2019), however are much less prevalent than cats. They are likely restricted more to the coast, wetter areas and infrastructure corridors. Because of their low prevalence in the area, likely similar effect on bilby populations and likely similar response to management, for the purpose of this plan, foxes will be referred to together with cats as “introduced predators”.

2.2 Inappropriate Fire Regimes

Intense and large landscape scale wildfires destroy, in a single event, large areas of habitat that provide food resources and cover from predation. Such fires also remove food resources beyond the range of travel of the bilby and increases vulnerability to predation (Johnson 2008; Woinarski *et al.* 2014). Intense and large fires attract and result in an increase of feral cats from afar (McGregor *et al.* 2014; McGregor *et al.* 2016). On the other hand, if areas are left too long without burning, vegetation matures (i.e. ground cover vegetation approaches and exceeds 35%), and in these areas ground cover vegetation becomes largely impenetrable to bilbies (Bradley *et al.* 2015).

Bilby populations require smaller, more frequent fires that create a mosaic of different age classes of regrowth, which increase habitat and resource diversity (Southgate and Carthew 2006; Southgate and Carthew 2007; Southgate *et al.* 2007b).

2.3 Interaction of Fire and Feral Predators

In north-western Australia, cats strongly select areas recently burnt by intense fires, in habitats that typically support high abundance of small mammals (McGregor *et al.* 2014). Intense fires create conditions that are favoured by cats, probably because hunting success is improved (McGregor *et al.* 2014). Cats undertake expeditions of up to 12.5 km from their home ranges to hunt over recently burned areas. Cats are especially likely to travel to areas burned at high intensity, probably in response to vulnerability of prey soon after such fires, and this behaviour increases the aggregate impact of cats on vulnerable prey (McGregor *et al.* 2016).

2.4 Introduced herbivores

Introduced herbivores include feral species (e.g. feral goats, camels, donkeys, rabbits, etc), and both unmanaged and domestic livestock. Introduced herbivores of significance as threats to bilby populations on the Dampier Peninsula include feral donkeys (*Equus asinus*) and cattle (*Bos taurus*), both domestic and unmanaged. Introduced herbivores remove vegetative cover and cause soil compaction; these effects are greater closer to water points (Bradley *et al.* 2015). Herbivores also congregate along drainage lines, which can often be important bilby habitat. Bilby occurrence correlates with an absence or low abundance of livestock (Southgate 1990).

Feral donkeys are prevalent across the Dampier Peninsula, but have been observed doing most damage in freshwater wetlands, which are not bilby habitat, with little sign of donkeys at locations where bilbies are present (pers comm Traditional Owner Ranger Groups). Domestic cattle are most common on the pastoral leases, with some but not many unmanaged cattle observed outside pastoral leases (pers comm Traditional Owner Ranger Groups). Free water availability associated with pastoralism at artificial water points for stock enables cats and foxes to spread and persist during dry/humid seasons (Bradley *et al.* 2015).

2.5 Land Clearing

Land clearing decreases bilby numbers through direct loss of habitat, degraded habitat surrounding the clearing, increased predation and fragmentation of sub-populations. Surrounding habitat can become degraded through changes to hydrology, weeds and by attracting increased numbers of predators (Bradley *et al.* 2015). Similar to surrounding regions (e.g. La Grange Irrigated Agriculture Opportunities area), a trend towards land clearing for irrigated agricultural development has the potential to also occur on the Dampier Peninsula. Concurrently, a growing trend towards mining minerals from sandy areas (e.g. rare earths, potash, mineral sands, basic raw materials) which overlays bilby habitat and populations, is already occurring on the Dampier Peninsula (e.g. Sheffield Resources Ltd's Thunderbird Minerals sands Project – EPA Assessment No. 2073, EPBC Act 2017/968).

The threatening effects of land clearing are manifested on a local, as well a landscape scale over a longer period of time. Localised clearing can lead to the loss

of populations and important bilby habitat, linear infrastructure may affect movement and dispersal and lead to fragmentation and loss of geneflow between populations (eg Epps *et al.* 2005; Holderegger and Di Giulio 2010). Widespread land clearing over the long term (30-50 years), through the accumulation over time and space of localised land clearing for development, can lead to a gradual and unrecognised loss of function of an entire ecosystem (for example the Western Australian Wheatbelt: Saunders 1989; Hobbs 1993).

2.6 Road Kills

Roads on which vehicles travel at night and at speed can result in road kills of individual bilbies in areas where bilbies are present or move through (Bradley *et al.* 2015). Major roads on the Dampier Peninsula include the Cape Leveque Road, Great Northern Highway, and the Broome Road. Bilby populations exist near, or along these roads (NatureMap 2019). Vehicle-induced mortality on mammals is well documented (Forman and Alexander 1998; Taylor and Goldingay 2004; Coffin 2007; Taylor and Goldingay 2010), and several road kills of bilbies have been documented along the Cape Leveque Road (M. Dziminski, pers obs).

3 Threat and Management Assessment Process

This plan uses a qualitative threat assessment process to analyse and assess relative risk of known and potential threats, and the performance and efficiency of management actions. This process uses the template recommended in the *Threatened Species Status Assessment Manual* (Department of Environment and Energy 2015), with some modifications to adapt it to this project, and provides an evidence-based assessment.

Difference in risk was calculated to determine management actions that provide the greatest benefit. Relative cost of management actions was rated to determine the value of the action in relation to the net benefit of the action (difference in risk). Each management action was also rated whether it fell within the budget of this project and whether the scope or particular offset conditions of this project would allow the management action to be undertaken.

The Threat and Management Assessment Process is shown in Table 1. The highest threat assessed for wild bilby populations on the Dampier Peninsula is the interaction of fire and introduced predators Table 1.

Table 1. Threat and Management Assessment Process for the Dampier Peninsula Bilby Offset Project.

IDENTIFICATION				ANALYSIS									TREATMENT						NET BENEFIT	FEASIBILITY AND IMPLEMENTATION		
1 #	2 Threats	3 Impact	4 Sources of the threat	6 Inherent threat rating (What is the threat rating before any management strategies are in place?)			7 Existing conservation management strategies for each source of the threat		8 Residual threat rating (Assess the consequences and their likelihood taking into account the effectiveness of the existing controls)			9		12 Target threat rating (What is the expected threat rating after additional treatments are in place?)			13 Difference in risk	14		
				6A Consequence	6B Likelihood	6C Rating	7A Management strategies in place	7B Select from the Control Rating	8A Consequence	8B Likelihood	8C Rating	9A Proposed threat treatments	9B Select from the Control Rating	12A Consequence	12B Likelihood	12C Rating		14A Cost	14B Within Project Budget?	14C Does the project scope allow it?
1	Interaction of fire and feral predators	Impact on population and disruption to breeding cycle	Fire and burnt areas attract increased predator numbers and activity	Major	Almost Certain	**Severe 35**	NIL		Major	Almost Certain	**Severe 35**	Effective and constant fire management across whole of Dampier Peninsula with concurrent annual aerial Eradicat® baiting of the whole Dampier Peninsula and targeted trapping/hunting	Strong	Minor	Possible	**Low 6**	**-29**	High	No	No
			Large burnt areas with no neighbouring unburnt patches provide no cover or concealment from predators									Effective and constant fire management across whole of Dampier Peninsula with concurrent annual targeted ground Eradicat® baiting and targeted trapping/hunting at bilby populations and buffer area	Adequate	Moderate	Possible	**Medium 9**	**-26**	Medium	No	No
												Localised fire management around bilby populations - fire breaks and patch mosaic burning with some burns in late spring or early summer to improve *Yakirra* production with concurrent annual targeted ground Eradicat® baiting and targeted trapping/hunting at bilby populations and buffer area	Adequate	Moderate	Possible	**Medium 12**	**-23**	Low	Yes	No

IDENTIFICATION				ANALYSIS									TREATMENT					NET BENEFIT	FEASIBILITY AND IMPLEMENTATION		
1 #	2 Threats	3 Impact	4 Sources of the threat	6 Inherent threat rating (What is the threat rating before any management strategies are in place?)			7 Existing conservation management strategies for each source of the threat		8 Residual threat rating (Assess the consequences and their likelihood taking into account the effectiveness of the existing controls)			9		12 Target threat rating (What is the expected threat rating after additional treatments are in place?)			13 Difference in risk	14		
				6A Consequence	6B Likelihood	6C Rating	7A Management strategies in place	7B Select from the Control Rating	8A Consequence	8B Likelihood	8C Rating	9A Proposed threat treatments	9B Select from the Control Rating	12A Consequence	12B Likelihood	12C Rating		14A Cost	14B Within Project Budget?	14C Does the project scope allow it?
2	Widespread land clearing over the long term (30-50 years) through accumulation over time and space of localised land clearing for development (e.g. WA Wheatbelt)	Impact on the habitat critical to the survival of the species and fragmentation of habitat/loss of habitat connectivity reducing the areas of occupancy	Destruction of key habitat by clearing	Critical	Unlikely	**High 30**	Referal to Commonwealth under EPBC Act	Weak	Critical	Unlikely	**High 30**	Coordinated management of development to ensure large tracts of connected suitable habitat remain to support wild populations	Adequate	Moderate	Possible	**Medium 9**	**-21**	High	No	No
			Fragmentation of key habitat by linear infrastructure (road/rail)									Purchase large tracts of land specifically for bilby conservation reserves	Adequate	Minor	Possible	**Low 6**	**-24**	High	No	No
			Infrastructure attracts increased predator numbers/activity																		
3	Predation by feral cats and foxes	Impact on population and disruption to breeding cycle	High feral cat and/or fox occupancy and activity resulting in increased predation mortality and decline in numbers of bilbies	Major	Likely	**High 28**	NIL		Major	Likely	**High 28**	Annual aerial Eradicat® baiting of whole Dampier Peninsula and targeted trapping/hunting	Strong	Minor	Possible	**Low 6**	**-22**	Medium	No	No
			Disruption of breeding cycle by high feral cat and/or fox occupancy and activity resulting in targeted predation of juveniles thus preventing reproduction cycle occurring									Annual targeted ground Eradicat® baiting and targeted trapping/hunting at bilby populations and buffer area	Adequate	Moderate	Possible	**Medium 9**	**-19**	Low	Yes	No
												Targeted trapping/hunting at bilby populations	Weak	Major	Likely	**High 28**	**0**	Low	Yes	No

IDENTIFICATION				ANALYSIS									TREATMENT					NET BENEFIT	FEASIBILITY AND IMPLEMENTATION		
1 # 2 Threats 3 Impact 4 Sources of the threat				6 Inherent threat rating (What is the threat rating before any management strategies are in place?)			7 Existing conservation management strategies for each source of the threat		8 Residual threat rating (Assess the consequences and their likelihood taking into account the effectiveness of the existing controls)			9		12 Target threat rating (What is the expected threat rating after additional treatments are in place?)			13 Difference in risk	14		
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4	Inappropriate fire regime	Impact on the habitat critical to the survival of the species	Large landscape scale wildfire destroys large areas of habitat in a single event reducing diversity in regrowth age, food resources and cover and opportunities for concealment from predators	Moderate	Likely	**Medium 12**	Dampier Peninsula Fire Plan and planned burning	Incomplete	Moderate	Possible	**Medium 9**	Localised fire management around bilby populations - fire breaks and patch mosaic burning with some burns in late spring or early summer to improve *Yakirra* production	Adequate	Minor	Unlikely	**Low 4**	**-5**	Low	Yes	Yes
			Long unburnt areas result in vegetation being too thick for bilbies to occupy									Effective and constant fire management across whole of Dampier Peninsula	Strong	Insignificant	Unlikely	**Low 2**	**-7**	High	No	Yes
			Fire at not the correct time during the annual cycle reducing production of key food species																	
5	Road kills	Impact on population	Road kills by vehicles travelling at night at speed on main roads	Minor	Almost Certain	**Medium 10**	NIL		Minor	Almost Certain	**Medium 10**	Low speed limits at night enforced near bilby populations	Adequate	Minor	Possible	**Low 6**	**-4**	Low	Yes	No
												Altering vegetation using fire to make habitat surrounding roads unsuitable bilby habitat	Adequate	Minor	Possible	**Low 6**	**-4**	Medium	Yes	No
												Speed reduction devices/limits, safe underpasses, suitable fencing/virtual fencing and automatic auditory wildlife warning devices along roads near bilby populations	Weak	Minor	Likely	**Medium 8**	**-2**	High	No	No

IDENTIFICATION				ANALYSIS									TREATMENT					NET BENEFIT	FEASIBILITY AND IMPLEMENTATION		
1 # 2 Threats 3 Impact 4 Sources of the threat				6 Inherent threat rating (What is the threat rating before any management strategies are in place?)			7 Existing conservation management strategies for each source of the threat		8 Residual threat rating (Assess the consequences and their likelihood taking into account the effectiveness of the existing controls)			9		12 Target threat rating (What is the expected threat rating after additional treatments are in place?)			13 Difference in risk	14		
				6A Consequence	6B Likelihood	6C Rating	7A Management strategies in place	7B Select from the Control Rating	8A Consequence	8B Likelihood	8C Rating	9A Proposed threat treatments	9B Select from the Control Rating	12A Consequence	12B Likelihood	12C Rating		14A Cost	14B Within Project Budget?	14C Does the project scope allow it?
6	Localised land clearing for development	Impact on the habitat critical to the survival of the species and fragmentation of habitat/loss of habitat connectivity thereby reducing the areas of occupancy	Destruction of key habitat by clearing	Minor	Likely	**Medium 8**	Native vegetation clearing permits	Adequate	Minor	Likely	**Medium 8**	Purchase land specifically for bilby conservation reserves	Adequate	Minor	Possible	**Low 6**	**-2**	High	No	No
			Fragmentation of key habitat by linear infrastructure (road/rail)																	
			Infrastructure attracts increased predator numbers/activity																	
7	Grazing by feral, domestic and unmanaged stock	Impact on the habitat critical to the survival of the species	High densities of feral donkeys overgrazing habitat, degrading and causing erosion at key habitat	Minor	Possible	**Low 6**	NIL		Minor	Possible	**Low 6**	Fencing off areas for bilbies (large areas required to be fenced due to movement of bilby populations)	Incomplete	Minor	Possible	**Low 6**	**0**	High	No	Yes
												Aerial culling of feral donkeys and unmanaged cattle on the Dampier Peninsula	Strong	Insignificant	Unlikely	**Low 2**	**-4**	High	No	Yes
												Opportunistic ground culling of feral donkeys and unmanaged cattle	Weak	Minor	Possible	**Low 6**	**0**	Low	Yes	Yes
												Shutting or moving artificial water point if one exists near bilby population	Weak	Minor	Unlikely	Low 4	-2	Medium	Yes	Yes

4 Management Actions

Many possible management actions exist, and the details of many of these can be found in the Federal Government's Threat Abatement Plans (Department of Environment and Energy 2019b) and Listed Key Threatening Processes (Department of Environment and Energy 2019a). Only management actions that would be possible to implement within the budget of the Dampier Peninsula Bilby Offset Project are considered in detail below.

4.1 Management Actions within the budget of the Dampier Peninsula Bilby Offset Project

4.1.1 Managing Introduced Predators (Feral Cat Focussed)

Feral cat populations must be suppressed and managed to mitigate impacts in targeted areas where they pose the greatest threat to biodiversity (Commonwealth of Australia 2015). Details on feral cat management can be found in the *The Threat Abatement Plan for Predation by Feral Cats* (Commonwealth of Australia 2015) and recommendations are:

- Shooting feral cats is expensive, labour intensive and time consuming and is typically only done on a relatively small scale;
- Like shooting, trapping as a control method is usually expensive, labour intensive and time consuming, and is only recommended on a small scale;
- Predator proof fencing is expensive and requires ongoing maintenance to ensure its predator-proof integrity;
- Baiting for feral cats is a broad-scale technique that has potential to reduce feral cat populations over larger areas. The Eradicat® bait is injected with 1080 and may be used in Western Australia. This bait is effective when applied strategically to target the feral cats when they are hungry (Christensen *et al.* 2013; Algar *et al.* 2013).

Furthermore, grooming traps are only in the early stage of development, and therefore currently expensive and unavailable (Ecological Horizons 2019).

Ideally, annual strategic aerial Eradicat® (Algar and Burrows 2004; Algar *et al.* 2013; Doherty and Algar 2015) baiting of the whole Dampier Peninsula would be undertaken. However, localised strategic ground baiting of managed bilby populations and surrounding buffer zones, coupled with supplementary trapping (Molsher 2002; Algar *et al.* 2013), and traditional hunting (Taylor 2015), would be an effective technique to control feral cats and opportunistically foxes at and around these bilby populations.

4.1.2 Fire Management

Bilby populations require smaller, more frequent fires that create a mosaic of different age classes of regrowth, that increase habitat and resource diversity

(Southgate and Carthew 2006; Southgate and Carthew 2007; Southgate *et al.* 2007b). Large, intense wildfires must be prevented from impacting bilby populations, and the ground vegetation in areas where bilby populations exist should not be allowed to become too dense which prevents bilbies from remaining, and supplies a high fuel load for wildfires.

Although landscape scale fire management is certainly beneficial for bilby populations, management on this scale is outside the budget of the Dampier Peninsula Bilby Offset Project. Landscape scale fire management is being planned and undertaken under the Dampier Peninsula Fire Management Planning Project (Rangelands NRM 2018). In this plan, localised fire management with specific benefits to bilby populations is a key objective, rather than the large scale, general benefits planned under the Dampier Peninsula Fire Management Planning Project.

Localised fire management should include:

- Establishing a suitable firebreak surrounding managed populations to prevent large wildfires destroying vegetation structure and food resources (Wright and Clarke 2007) and allowing easy predator access (McGregor *et al.* 2014; Doherty *et al.* 2015) within managed populations;
- Implementing patch mosaic burning to create fire age heterogeneity, increasing habitat and resource diversity for bilbies (Southgate and Carthew 2006; Southgate and Carthew 2007; Southgate *et al.* 2007a);
- Some patch burns conducted in late spring or early summer to improve *Yakirra* (*Yakirra australiensis* – bunch panicum) production (Southgate and Carthew 2007).

4.1.3 Management of the Interaction of Fire and Introduced Predators

Fire management and burning at and around bilby populations may attract introduced predators to the existing bilby population. Cats select areas recently burnt by fires, (McGregor *et al.* 2014) and undertake expeditions of up to 12.5 km from their home ranges to hunt over recently burned areas (McGregor *et al.* 2016). Therefore, the best practice management needs to manage both fire and introduced predators concurrently to avoid this effect. This could be achieved by combining localised fire management with localised introduced predator management, using the techniques described above in Sections 4.1.1 and 4.1.2.

4.1.4 Introduced Herbivore Management

Fencing introduced herbivores off from the large areas bilby populations require for persistence and large scale aerial shooting are not within the budget of this project. The remaining viable introduced herbivore management options include aerial or opportunistic ground shooting of feral donkeys and unmanaged cattle. Trapping at watering places has variable results as some areas have too many alternative water sources. Feral donkeys are difficult to muster because of their habit of breaking away when driven. Shooting from the ground is difficult in rough terrain (DPIRD 2019). A possibility may be to negotiate to close artificial water points in the vicinity of

managed bilby populations in the unlikely event this situation occurs (Bradley *et al.* 2015).

4.1.5 Management to reduce Road Kills

The Dampier Peninsula Bilby Offset Project is focussed on bilby populations on the Dampier Peninsula away from the development of the Cape Leveque Road. Management of bilby populations along the Cape Leveque Road and techniques to reduce road kills are covered in the *Cape Leveque Road Upgrade Greater Bilby Management Plan* (GHD 2014), and therefore not addressed in this document.

5 Recommended Management

A summary of potential management actions that are within the budget of the Dampier Peninsula Bilby Offset Project is shown in Table 2. The management action with the most efficiency and value for effort is localised fire management combined with concurrent localised introduced predator management (Table 2). This action reduces the effects of the interaction of fire and feral predators and results in a net reduction of the threat rating by -23, reducing it from Severe to Medium (Table 2). The action with the least benefit is managing introduced herbivores (Table 2).

Unfortunately, the scope of the Dampier Peninsula Bilby Offset Project does not allow any management of introduced predators, and any management actions are severely limited by the offset conditions to only include fire management and the management of introduced herbivores. This is despite the fact that the effects of the interaction of introduced predators with fire, and introduced predators on their own are a higher threat to bilby populations. Burning without consideration to predator management at wild bilby populations may attract introduced predators influencing, and potentially causing a higher threat level. There may be scope to partner with other organisations that may be able to provide funding and resources for concurrent introduced predator management at these bilby populations, and the pursuit of this option is strongly encouraged. This would provide a higher return for management invested, and lead to a much greater reduction in threat level.

The summary of remaining available management options are shown in Table 3. Little sign of donkeys has been found at locations where bilbies are present (pers comm Traditional Owner Ranger Groups), therefore, apart from a minor effect on feral donkeys, any introduced herbivore management involving cattle would be largely ineffective. This is because most cattle on the Dampier Peninsula are found on pastoral tenure, and pastoralists have restricted access to their leases for this project and similar projects in the region (Dziminski *et al.* 2018). Since pastoralists are reluctant to provide access, any cattle management actions would be ineffectual to attempt in the current situation.

The area of management surrounding bilby populations needs to be large enough to create habitat heterogeneity and accommodate movement of the population within the managed area (Southgate and Possingham 1995; Southgate *et al.* 2007a; Southgate and Carthew 2007). From pilot studies in the Pilbara and Kimberley, the area of management surrounding populations will need to be between 2 000 to 10 000 ha depending on geography. Two to three wild bilby populations will be located and selected for management of threats. Management will include:

- Fire management:
  i) Establishing a suitable firebreak surrounding managed populations to prevent large wildfires destroying vegetation structure and food resources (Wright and Clarke 2007) and allowing easy predator access (McGregor *et al.* 2014; Doherty *et al.* 2015) within managed populations;

ii) Implementing patch mosaic burning to create fire age heterogeneity, increasing habitat and resource diversity for bilbies (Southgate and Carthew 2006; Southgate and Carthew 2007; Southgate et al. 2007a);
iii) Some patch burns conducted in late spring or early summer to improve *Yakirra* production (Southgate and Carthew 2007).

- Livestock management:
  i) Negotiating to close artificial water points in the vicinity of managed populations in the unlikely event this situation becomes relevant.

No management will occur at two to three control populations. Bilby population monitoring and concurrent predator and introduced herbivore occupancy monitoring will occur at all sites. Once commenced, management will be ongoing. Traditional Owner ranger groups will be involved in monitoring, and provide on-ground operations for all management works. Training will be provided as part of the partnership in this project.

Bilby population monitoring will be undertaken using the technique developed and now implemented by DBCA, using DNA extracted from quantitatively collected scats (Dziminski and Carpenter 2017). This is currently the only technique available for accurately and reliably measuring population size for bilbies. Concurrent occupancy monitoring of introduced predators, feral donkeys and livestock will be undertaken using:

1. Remote camera array using five cameras spaced across each population;
2. 2 ha sign plot array with plots spaced across each population.

Population monitoring will be undertaken at each site prior to management and then after management is implemented. This experimental approach follows a before-after-control-impact (BACI) design (Downes 2002). It is envisaged that this project will be a catalyst to initiate management and monitoring at these population with future ongoing management and monitoring continuing and expanding.

Bilby populations can respond rapidly to favourable conditions (McCracken 1990; Southgate *et al.* 2000; Ballantyne *et al.* 2009; Johnston *et al.* 2010; Miller *et al.* 2010). It is expected that the abundance of bilbies within managed populations will increase. This design will test the hypothesis that management has a positive effect on the abundance of bilbies.

The population monitoring and management will link with work currently being undertaken by the DBCA and Traditional Owner Ranger Groups on the Dampier Peninsula in the Kimberley, Pilbara and Western Desert regions. By using these standardised techniques, this project will contribute to a broader knowledge of the status of bilby populations and the effectiveness of management of threats across Northern Australia. Outcomes will improve the effect and efficiency of management of threats by government, industry and natural resource management agencies to ensure wild bilby populations remain in the Kimberley and do not disappear as in other parts of their former range.

Table 2. Potential management actions that are within the budget of the Dampier Peninsula Bilby Offset Project.

Threats addressed and rating	Management action	Net benefit and rating
Interaction of fire and feral predators SEVERE 35	Localised fire management around bilby populations - fire breaks and patch mosaic burning with some burns in late spring or early summer to improve *Yakirra* production with concurrent annual targeted ground Eradicat® baiting and targeted trapping/hunting at bilby populations and buffer area	-23 MEDIUM 12
Predation by feral cats and foxes HIGH 28	Annual targeted ground Eradicat® baiting and targeted trapping/hunting at bilby populations and buffer area	-19 MEDIUM 9
	Targeted trapping/hunting at bilby populations	0 HIGH 28
Inappropriate fire regimes MEDIUM 9	Localised fire management around bilby populations - fire breaks and patch mosaic burning with some burns in late spring or early summer to improve *Yakirra* production	-5 LOW 4
Grazing by feral donkeys and domestic stock, including unmanaged cattle LOW 6	Shutting or moving artificial water point if one exists near bilby population	-2 LOW 4
	Opportunistic ground culling of feral donkeys and unmanaged cattle	0 LOW 6

Table 3. Potential management actions that are within the budget and within the scope of funding of the Dampier Peninsula Bilby Offset Project.

Threats addressed and rating	Management action	Net benefit and rating
Inappropriate fire regimes MEDIUM 9	Localised fire management around bilby populations - fire breaks and patch mosaic burning with some burns in late spring or early summer to improve *Yakirra* production	-5 LOW 4
Grazing by feral donkeys, and unmanaged cattle LOW 6	Shutting or moving artificial water point if one exists near bilby population	-2 LOW 4
	Opportunistic ground culling of feral donkeys and unmanaged cattle	0 LOW 6

6 Locations of proposed actions

The locations of the proposed actions are shown in Figure 2.

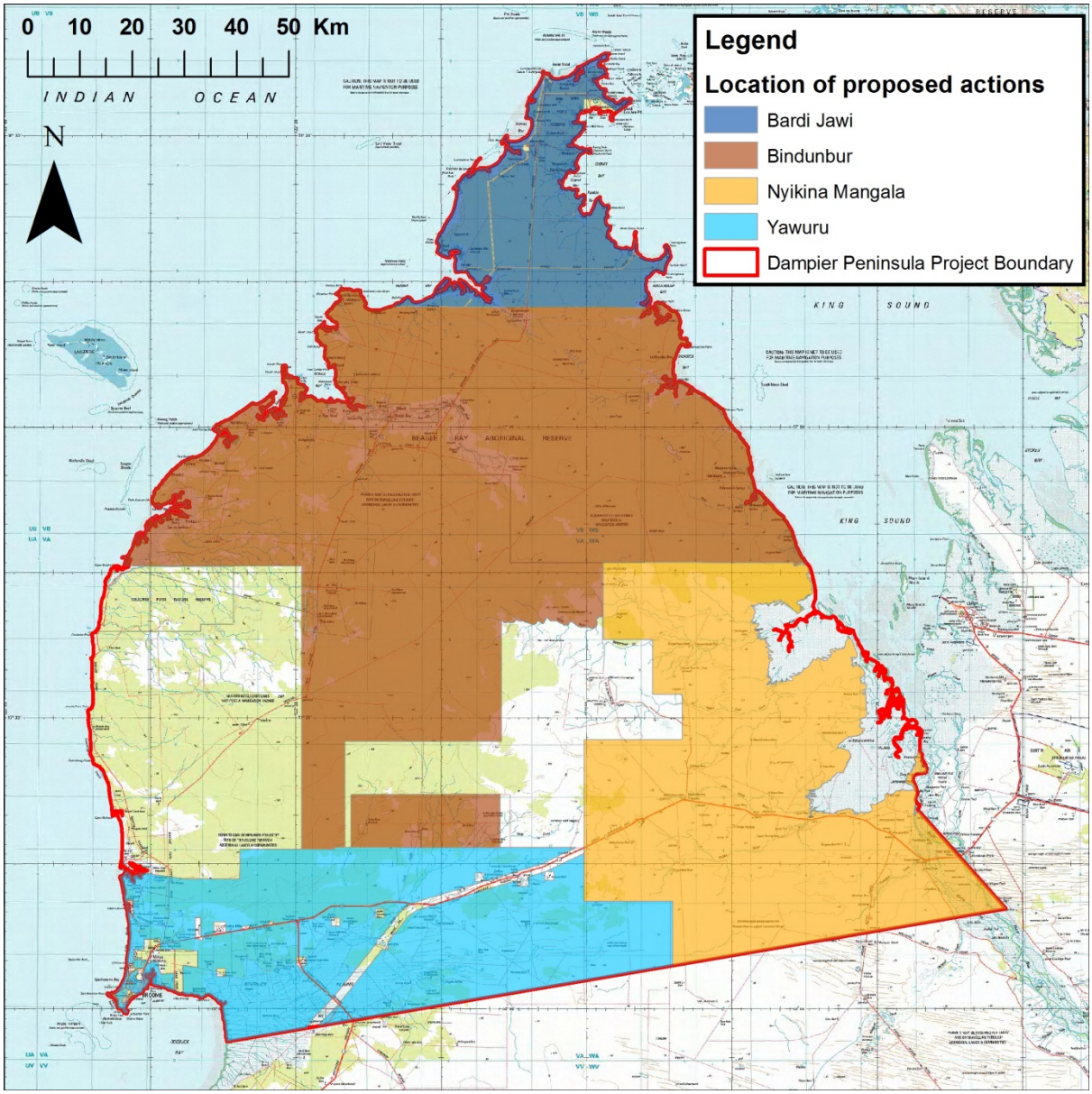

Figure 2. Location of the proposed actions. Proposed management will occur at two to three wild bilby populations within the highlighted locations. Monitoring of two to three control populations will also occur within these areas.

7 Timeframes for implementation

2019												
Milestone	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Locate and identify 2 - 3 bilby populations to undergo threat management and 2 – 3 control populations												
Abundance monitoring: Complete field component (scat collection transects) at all management and control populations												
Remote cameras deployed to monitor occupancy												
Complete written fire management plan and obtain permits for the 2 - 3 management sites in accordance with Dampier Peninsula Bilby Offset Project Threat Management Plan												
Implementation of Fire Management Plan: Commence burning 2019												
Identify optional feral herbivore management actions (i.e.. movement of water points) and complete negotiations and plan for implementation in accordance with Dampier Peninsula Bilby Offset Project Threat Management Plan												
DNA extractions and genotyping to be completed for monitoring populations												
Scoring/analyses of remote camera images												
Complete 2020 work plan												

2020												
Milestone	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Complete written fire management plan and obtain permits for the 2 - 3 management sites in accordance with Dampier Peninsula Bilby Offset Project Threat Management Plan												
Scoring/analyses of remote camera images												
Implement optional feral herbivore management actions (i.e.. movement of water points) in accordance with Dampier Peninsula Bilby Offset Project Threat Management Plan												
Progress report												
Remote cameras deployed to monitor occupancy												
Implementation of Fire Management Plan												
Complete 2021 work plan												

2021												
Milestone	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Complete written fire management plan and obtain permits for the 2 - 3 management sites in accordance with Dampier Peninsula Bilby Offset Project Threat Management Plan												
Scoring/analyses of remote camera images												
Progress report												
Abundance monitoring: Complete field component (scat collection transects) at all management and control populations												
Remote cameras deployed to monitor occupancy												
Implementation of Fire Management Plan												
DNA extractions and genotyping to be completed for monitoring populations												
Final report				2022								

8 Indicative breakdown of funding for proposed actions

Year	2019	2020	2021	Total
Salary (Field Officer)	$25,000	$25,000	$25,000	$75,000
Fire Management	$8,000	$8,000	$8,000	$24,000
Travel (flights/vehicles)	$6,500	$6,500	$6,500	$19,500
TO Rangers (Fee for service)	$25,000	$25,000	$25,000	$75,000
Bilby abundance monitoring	$40,000		$40,000	$80,000
Remote cameras	$6,000			$6,000
Total				$279,500

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Appendices

Appendix 1 Likelihood and consequence criteria, and the threat matrix.

Details can be found in the *Threatened Species Status Assessment Manual* (Department of Environment and Energy 2015).

Likelihood Criteria

Score	Likelihood	Description
1	Rare	The outcome is not expected to occur; never heard of but not impossible; may occur in exceptional circumstances
2	Unlikely	The outcome will only occur in a few circumstances; uncommon but know to occur elsewhere
3	Possible	The outcome may occur; some evidence to support it will happen
4	Likely	The outcome will occur in most circumstances
5	Almost certain	The outcome is expected to occur

Consequence Criteria

Consequence	Insignificant	Minor	Moderate	Major	Critical
	1	2	3	4	5
Impact on population[3]	Minimal impact on local population numbers; area affected negligible compared to total population; minimal or acceptable impact on population size	Minor impact on local population numbers. Population in other locations not impacted	Moderate impact on local population numbers. Some impacts on populations in other locations; moderate and/or short term effects	Major population reduction or loss of local population; recovery measure in years to decades; serious and significant impact on species	Population reduction which may results in species extinction; recovery period is greater than decades; very significant and serious impact on high value species
Fragmentation of habitat/loss of habitat connectivity/reduce the areas of occupancy[4]	Minimal losses of local habitat only, recovery likely in a relatively short period of time; threats are covered by current management or legislation	Minor losses of local habitat requiring recovery over short term	Moderate loss of local habitat requiring recovery over a short to medium term and resulting in loss of connectivity between habitats at a local scale	Loss of local habitat with no potential for recovery, or partial loss of habitat across large areas and/or with limited potential for recovery in the medium to long term. Results in a net reduction in connectivity over a large area	Complete loss of local habitat with no potential for recovery and loss of habitat in other locations with limited potential for recovery in the long term resulting in a significant impact on habitat connectivity over a large area

Consequence	Insignificant	Minor	Moderate	Major	Critical
	1	2	3	4	5
Impact on the habitat critical to the survival of the species[5]	Minimal modification, destruction, removal ore decrease of local habitat only, recovery likely in a relatively short period of time; insignificant impact to habitat or threat activity only occurs in a very small areas of habitat; limited damage to minimal area of low significance; minor effects on physical environment	Minor modification, destruction, removal ore decrease of local habitat requiring recovery over short term	Moderate modification, destruction, removal ore decrease of local habitat requiring recovery over a short to medium term and resulting in loss of connectivity between habitats at a local scale	Modification, destruction, removal or loss of local habitat with no potential for recovery, or partial loss of habitat across large areas and/or with limited potential for recovery in the medium to long term. Results in a net reduction in connectivity over a large area; habitat is affected which may endanger the species and habitat long term survival – 70-90% habitat affected or removed; 30% fragile habitat affected or removed; 10-20% critical habitat affected or removed;	Significant impact resulting in the removal, destruction, fragmentation and degradation of habitat; the entire habitat is in danger of being affected or removed, that >90% habitat, >50% fragile habitat , and >30% critical habitat

Consequence	Insignificant	Minor	Moderate	Major	Critical
	1	2	3	4	5
Disruption to breeding cycle[6]	Minimal impact on any aspect of the breeding cycle;	Minor disruption to the breeding cycle	Moderate disruption to breeding cycle resulting in modification of behaviour both within the direct impact zone and at nearby locations; long term recruitment and/or population dynamics are not adversely impacted	Direct impacts on breeding cycle resulting in a net decline in size of the population; the is limited information to judge the impact	Complete disruption of breeding cycles over several seasons with significant population decline and possible extinction
Impact of invasive species and/or disease[7]	Minimal impact on local population numbers or habitat quality	Minor impact on local population numbers or habitat quality. Population in other locations not impacted	Moderate impact on local population numbers or habitat quality. Some impacts on populations in other locations	Major population reduction or loss of local population or loss of habitat quality	Population reduction which may results in species extinction loss of critical habitat extent or quality

Consequence	Insignificant	Minor	Moderate	Major	Critical
	1	2	3	4	5
Interaction with species migration	Minimal impact on species migratory patterns	Results in minor behavioural modification on a local scale or impacts to physical conditions of animal interfering with migration for the short term only. Unlikely to negatively impact on the overall success of migration	Results in modification of behaviour or animal conditions such that there is potential for medium term impacts, with some possibility of individuals failing to complete migration	Results in modification of behaviour or animal condition such that there is potential for medium to long term impacts, both locally and in nearby locations, with some individuals failing to complete migration	Significant impact resulting in either complete failure, or failure of majority of individuals, to complete migration in that cycle

Threat Matrix

		Insignificant	Minor	Moderate	Major	Critical
		1	2	3	7	15
Almost Certain	5	5	10	15	35	75
Likely	4	4	8	12	28	60
Possible	3	3	6	9	21	45
Unlikely	2	2	4	6	14	30
Rare	1	1	2	3	7	15