Main Roads Western Australia (Wheatbelt Region)

Red-tailed Phascogale Assessment

Maintenance Zone Establishment – Toodyay-Goomalling Road (M060), Williams-Narrogin Highway (H053) and Pinjarra-Williams Road (M053)

Prepared for: Main Roads Western Australia (Wheatbelt Region)
PO Box 6202
East Perth, WA 6892

Prepared by: **Cameron Everard, Brenden Metcalf and Mike Bamford**
BAMFORD CONSULTING ECOLOGISTS
23 Plover Way
Kingsley, WA 6026

9th June 2017

Contents

List of tables

List of figures

List of plates

List of appendices

1 Introduction

1.1 Background

Main Roads Western Australia (Main Roads) is proposing to widen the maintenance zone along three roads in the Wheatbelt, including the Pinjarra - Williams Road (M053), Williams - Narrogin Highway (H053) and Toodyay - Goomalling Road (M060). It is understood that these roads have been identified as three of the most unsafe roads in the Wheatbelt due to the number of trees that occur within four metres (m) of the road seal and therefore represents a significant risk to drivers. Main Roads proposes to clear trees and upgrade infrastructure within this 4 m zone over the next 3 years (2017 – 2019).

The Maintenance Zone Establishment project was referred to the Federal Department of the Environment and Energy (DOEE) and deemed a Controlled Action (EPBC Ref 2016/7698, 29th June 2016). The relevant controlling provision was determined to be "Listed threatened species and communities" (Sections 18 and 18A) of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). To further inform the EPBC Act assessment, the DOEE has requested additional information on the Red-tailed Phascogale. The species is currently listed as Endangered under the EPBC Act and Schedule 6 (fauna that is of special conservation need as conservation dependent fauna) of the Western Australian *Wildlife Conservation Act 1950* (WC Act).

Bamford Consulting Ecologists (BCE) was commissioned by Main Roads to conduct a desktop assessment and field investigations on the Red-tailed Phascogale (*Phascogale calura*) with the following scope:

- Undertake a desktop review of previous reports from the vicinity of the project areas, including a regional assessment with biological justification that details available breeding habitat in the surrounding areas, and describes what proportion of available breeding habitat will be cleared as a result of the proposed action;
- Survey all three project areas in accordance with the DOEE survey guidelines for Australia's threatened mammals (Dept. of Sustainability, Environment, Water, Population and Communities, 2011); and
- Conduct an assessment of the direct and indirect impacts to the Red-tailed Phascogale as a result of the proposed action, including but not limited to:
    - loss of habitat;
    - loss of tree hollows; and
    - habitat fragmentation, including loss of roadside vegetation linkage.

The assessment therefore has the following components:

- Background information on the project and proposed methodology (Sections 1 and 2);
- Database searches and review of the scientific literature and previous studies on the Red-tailed Phascogale (Section 3);
- A field survey involving a habitat assessment and camera trapping (Section 4);
- An assessment of the risks and impacts upon the Red-tailed Phascogale (**Error! Reference source not found.**);and
- Advice on management strategies used to avoid and/or minimise impacts to the species (**Error! Reference source not found.**).

1.2 Project description

The project consists of three different road sections located in the Wheatbelt region of Western Australia (Figure 1). The road sections are located within existing road reserves managed by Main Roads and include a 4 m clearing zone from the road. Sections of road include:

1. **Toodyay-Goomalling Road (M060)** SLK (Straight Line Kilometres) 1.2 to SLK 48.0. From Toodyay east to Goomalling and comprises an area of 37.44 ha (located in the Shires of Toodyay and Goomalling);

2. **Williams-Narrogin Highway (H053)** SLK 0 to SLK 31.4. From Williams east to Narrogin and comprises an area of 25.12 ha (located in the Shires of Narrogin and Williams, and the Town of Narrogin); and

3. **Pinjarra-Williams Road (M053)** SLK 91.9 to SLK 125.5. From Quindanning east to Williams and comprises an area of 26.81 ha (located in the Shire of Williams).

The three projects cover an area of approximately 89.44ha (including 18.16 ha of native vegetation).

Note - areas above sourced from EPBC referral 2016-7698..

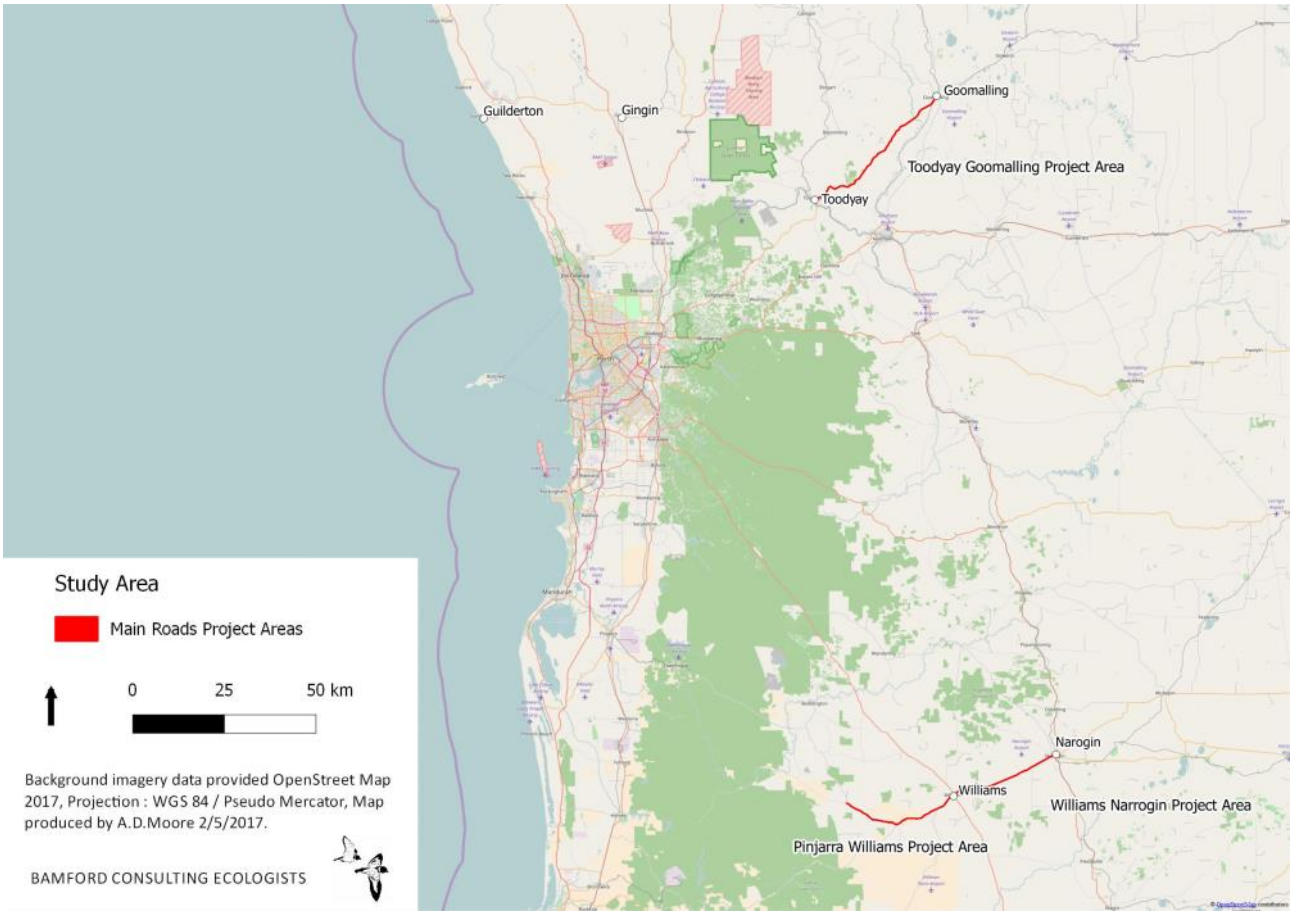

Figure 1. Location of the three study areas.

1.3 Red-tailed Phascogale Ecology and Threats

There is considerable published information on the ecology of, and threats to, Red-tailed Phascogale. Key references include:

- Action Plans (Maxwell *et al.* 1996);
- EPBC Survey Guidelines (DSEWPaC 2011);
- Draft Conservation Management Plan (Dept. of Environment and Conservation, no date);
- The Federal DoEE Species Profile and Threats (SPRAT) Database (DoEE 2017); and
- Scientific literature (Kitchener 1981; Friend and Scanlon 1996; Bradley 1997; Foster *et al.* 2006; Friend 2008; Short *et al.* 2011; Short and Hide 2012).

Summarising this work further, there are several salient points for assessing the potential value of the project footprint for Red-tailed Phascogales:

Key ecology

- The Red-tailed Phascogale is a small, arboreal and carnivorous dasyurid associated with *Eucalyptus wandoo* and *Allocasuarina huegeliana* woodland, with an approximate life span of two years. Males live for approximately 11.5 months before they die. The species occurs in the southern wheatbelt and persists in numerous small and large isolated nature reserves.

Key habitat requirements

- Red-tailed Phascogales are reliant on tree hollows in eucalypts (e.g. *E. wandoo*),logs and limbs in which to breed and show a preference for long (>20 years) unburnt habitat with a continuous canopy;
- The species is likely to occupy an area (of suitable habitat) approximately 3,000-3,500 km^2 (Short and Hide 2012); and
- Males die shortly after the mating period in July and they have been observed to increase their home range during this time. Home ranges vary from 1.5ha to 8ha, depending on the season, highlighting the need for contiguous habitat.

Key threats

- Key threatening processes include predation by cats and foxes, fragmentation and loss of habitat and frequent burning of habitat; and
- As a result of the semelparous (male die-off) lifecycle, the species is considered to be more susceptible to local extinction due to stochastic events.

2 Methodology

2.1 Desktop assessment

2.1.1 Database searches

Information on the Red-tailed Phascogale was drawn from a wide range of sources. These included state and federal government databases, and results of regional studies. Databases accessed were the Atlas of Living Australia Database, Department of Parks and Wildlife (DPaW) NatureMap (incorporating the Western Australian Museum's FaunaBase and the DPaW Threatened and Priority Fauna Database), the DOEE Species Profile and Threats Database and the BCE database (Table 1). Databases are a rich source of information as the region has been subject to several biological surveys and investigations. Such studies provide additional information on important sites, and local and regional context. Database searches were undertaken in February 2017.

Table 1. Database searches used for the desktop assessment.

Database	Type of records held on database	Area searched
Atlas of Living Australia (ALA 2017)	Records provided by collecting institutions, individual collectors and community groups.	Wheatbelt region and project area.
NatureMap (DPaW 2017)	Records in the WAM and DPaW databases. Includes historical records on Threatened and Priority species.	Wheatbelt region and project area.
SPRAT Database (DOEE 2017)	Species Profile and Threats Database.	-
BCE database (2017)	Records of fauna observations (1981-2017).	Fauna surveys and assessments in the Wheatbelt region.

2.1.2 Regional studies and project impact assessment reports

Information was sourced from scientific journal papers (Short and Hide 2012; Short *et al.* 2011) and regional management plans (DEC no date). A number of Environmental Impact Assessment (EIA) reports, including desktop assessments, field surveys and referrals (GHD 2016a; 2016b; 2016c) have been completed specifically for the project and were reviewed as a part of this assessment. Data on general patterns of distribution were supplemented from other sources such as Van Dyck and Strahan (2008), Maxwell *et al.* (1996) and Kitchener (1981) (Table 2). Key points from these studies are summarised in Section 3.2.

Table 2. Regional studies and project impact assessment reports.

Report/literature	Type of report	Study area
Short *et al.* (2011)	Habitat requirements of the red-tailed phascogale.	Southern wheatbelt of Western Australia
Short and Hide (2012)	Distribution and status of the red-tailed phascogale.	Southern wheatbelt of Western Australia
Red-tailed Phascogale Management Plan (DEC no date)	Draft Conservation Management Plan for Wheatbelt Populations of the Red-tailed Phascogale (2009-2014).	Wheatbelt region
GHD (2016a)	Biological survey to identify key flora, fauna, soil, groundwater and surface water values.	Project area
GHD (2016b)	EIA based on desktop and field investigations.	Project area
GHD (2016c)	Impact assessment of clearing – supporting information for the application of a clearing permit.	Project area
Van Dyck and Strahan (2008)	Mammals of Australia.	-

Report/literature	Type of report	Study area
Maxwell *et al*. (1996)	Action Plan for Australian Marsupials and Monotremes.	-
Kitchener (1981)	Breeding, diet and habitat preference of the Red-tailed Phascogale.	Southern wheatbelt of Western Australia

2.2 Field survey

2.2.1 Motion Camera surveys

Red-tailed Phascogales were surveyed within the three study areas using motion-sensitive cameras, as per the recommendations of DSEWPaC (2011). A total of 29 cameras were deployed within the study areas, for a period of 18-21 nights (see Table 3), resulting in a total of 465 trap nights. Cameras were placed in remnant/revegetated bushland areas adjacent to the three study areas. Cameras were generally placed within a metre of ground level and deployed with a bait tube positioned within the view to attract fauna and provide a scale to aid fauna identification (see Figure 2). Bait tubes contained a 'universal bait' mix of rolled oats, peanut butter and sardines. The location of each camera is shown in Figure 3 - Figure 5 and the GPS coordinates for each camera are listed in Appendix 1.

Figure 2. Example of camera trap set up. Top image shows position of MC045 (blue arrow) facing along a log with bait tube (red arrow) positioned within the camera view. Bottom image shows one of the photos taken with this camera, with the bait tube providing a scale to aid fauna identification.

Table 3. Number of camera traps and trapnights at each project area.

Project Area	No. of camera traps	Set – Pull Date	No. of trap nights
Toodyay–Goomalling Rd	9 deployed, 5 active[1]	15th Feb – 8th March 2017	(5 * 21) = 105
Pinjarra-Williams Rd	4	17th Feb – 7th March 2017	(4 * 18) = 72
Williams-Narrogin Rd	16	17th Feb – 7th March 2017	(16 * 18) = 288
TOTAL	**25**		**465**

2.2.2 Tree Hollow Assessment

Limited research has been conducted on the nest hollow requirements of Red-tailed Phascogales. Whitford's (2001) review of the requirements of hollow-nesting fauna includes the closely related but larger Brush-tailed Phascogale. The dimensions of hollows recorded as being used by Brush-tailed Phascogale include:

- Hollow entrance dimension 24mm to 28mm;
- Internal width of the hollow 80mm to 330mm; and
- Hollow depth 110mm to 3860mm.
- Minimum hollow entrance height was ground level (i.e. 0 metres).

Due to the smaller size of Red-tailed Phascogale, it is expected that at least the first two of these measurements could potentially be smaller in the hollows they utilise. In some arid areas of their former distribution, it is expected that any hollows available would be significantly smaller than those available to Brush-tailed Phascogales that are generally restricted to temperate forest areas.

Whitford (2002) found that ground-based tree hollow assessments are fraught with issues, resulting in both false-negative (i.e. trees recorded as having no suitable hollows due to suitable hollows not being visible from the ground) and false-positive (i.e. trees are recorded as having suitable hollows, that upon closer inspection are deemed unsuitable) records for potential hollows for a range of species. Rather than conducting 'hollow surveys', Whitford (2002) suggests using Diameter-at-Breast-Height (DBH) as a proxy for aging trees, with larger diameter (i.e. older) trees considered more likely to provide nest hollows. However Whitford (2001, 2002) focussed on Jarrah and Marri forest. These species do occur in the study area, but much of the overstorey vegetation is dominated by Wandoo (*Eucalyptus wandoo*), York Gum (*Eucalyptus loxophleba*) and Flooded Gum (*Eucalyptus rudis*) which were not assessed by Whitford (2002), although the same principle (that large trees have more hollows and thus a tree size assessment can act as a proxy for an actual hollow assessment) probably applies.

This lack of knowledge surrounding nest hollow usage for the Red-tailed Phascogale makes it very difficult to conduct a reliable assessment of suitable tree hollows within the study area. Therefore, the vegetation and vegetation types identified by GHD (2016a) were used as a surrogate for tree hollow availability. Vegetation types with Wandoo present (primarily Wandoo open woodland) were considered to be the most important for tree hollow supply.

[1] Although nine cameras were set, only five recorded images.

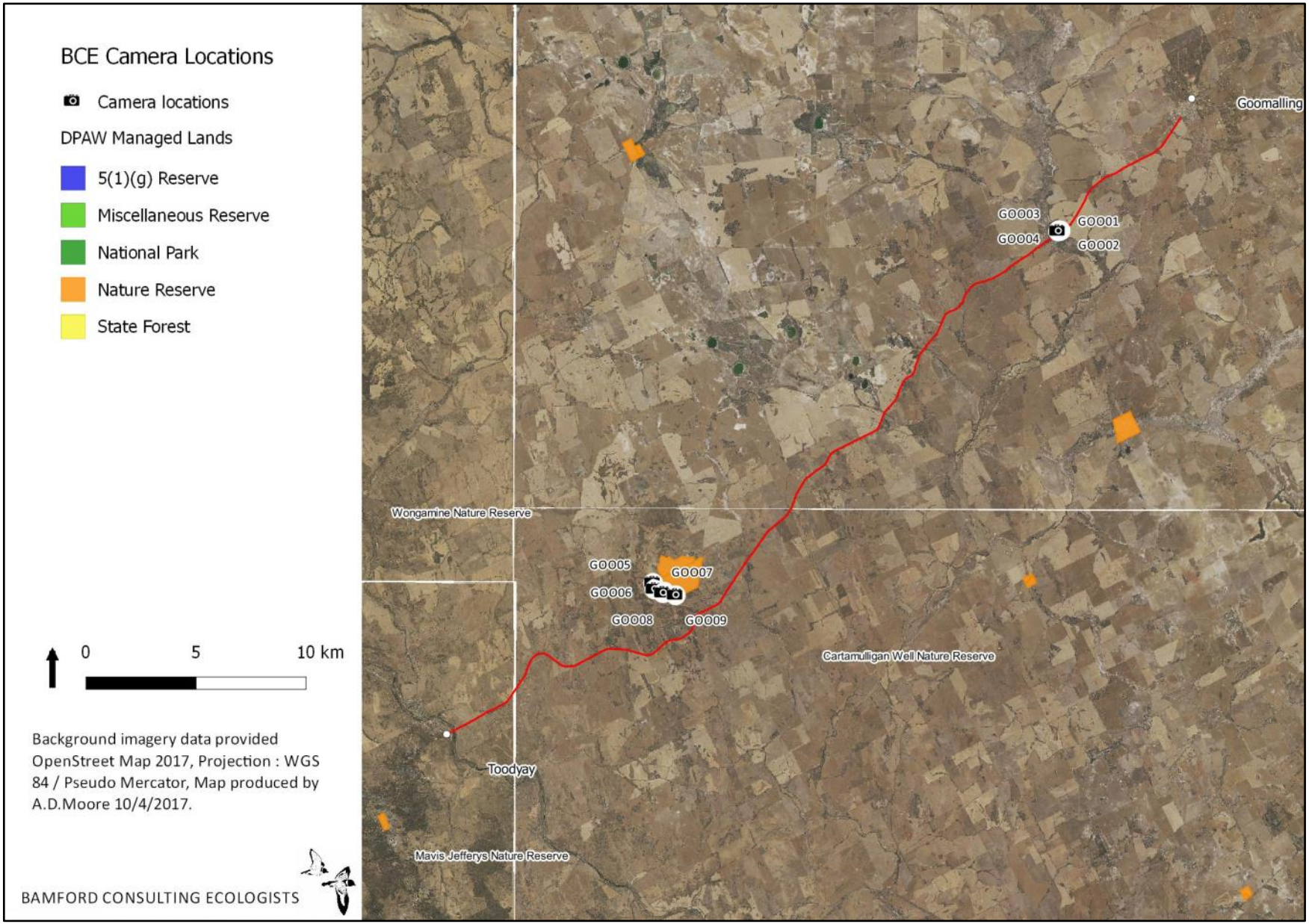

Figure 3. Motion Camera locations within the Toodyay to Goomalling Road study area

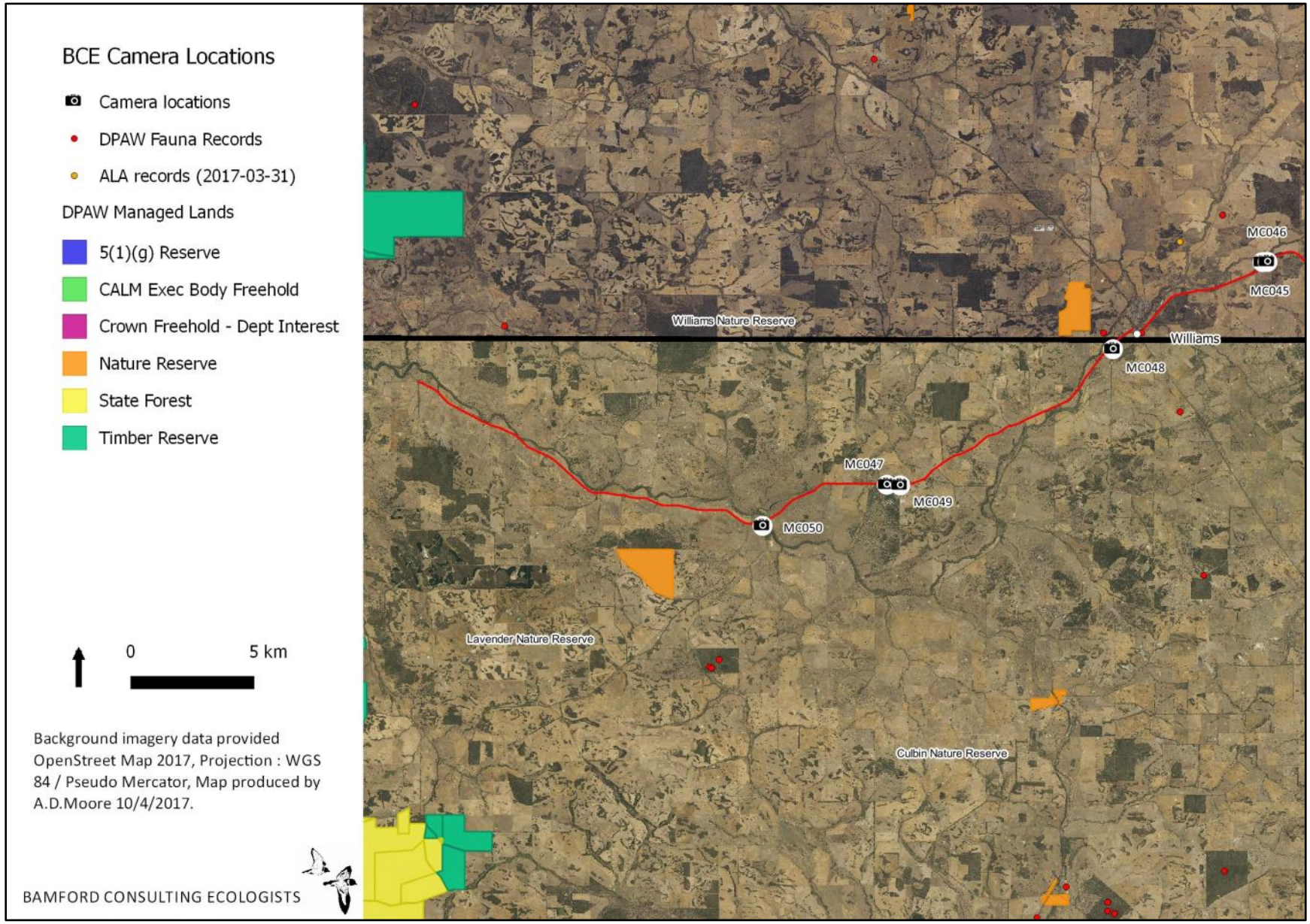

Figure 4. **Motion Camera locations within the Pinjarra to Williams Road study area.** Includes location of previous Red-tailed Phascogale records.

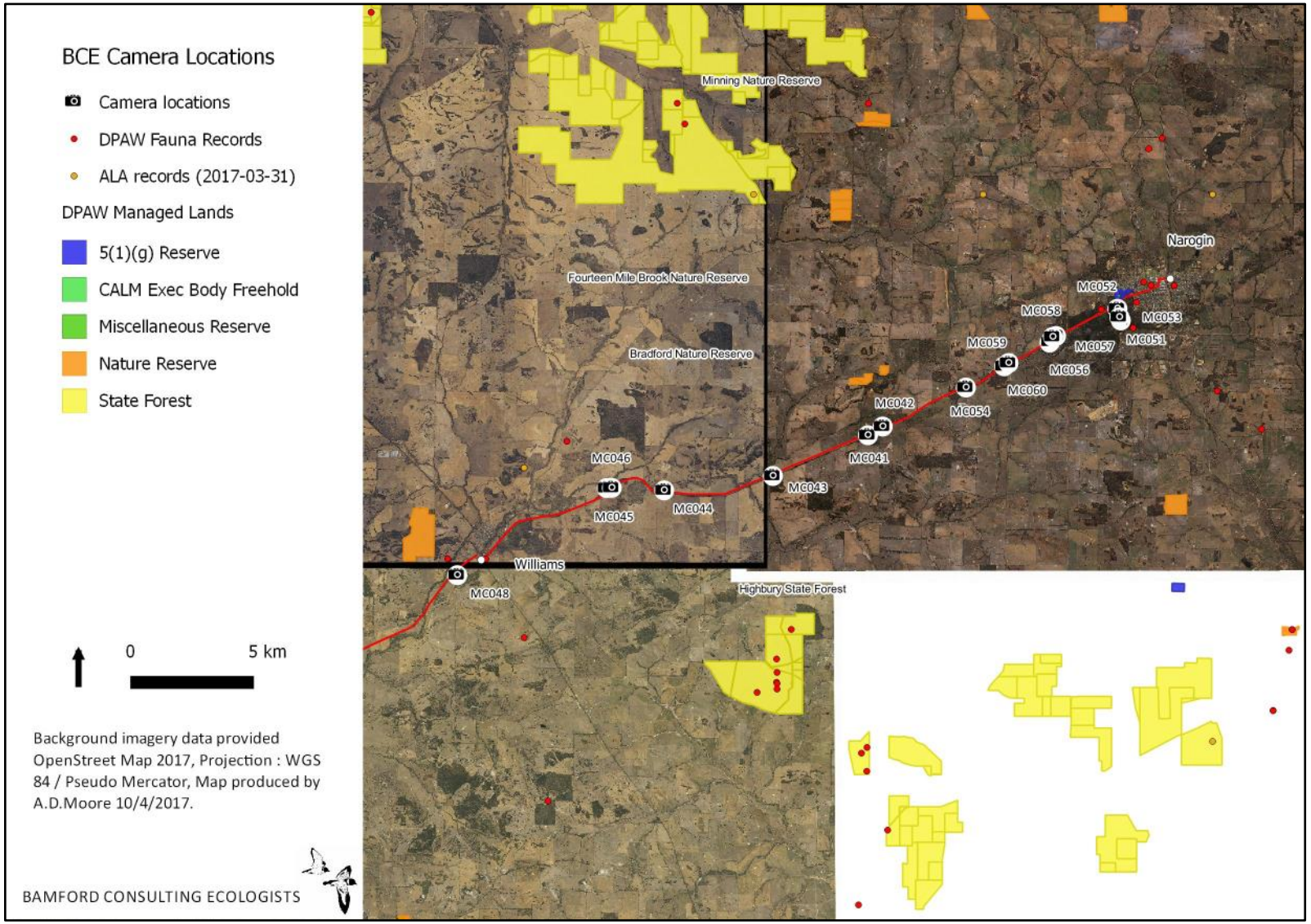

Figure 5. **Motion Camera locations within the Williams to Narrogin Highway study area.** Includes locations of previous Red-tailed Phascogale records.

2.3 Survey limitations

The Environmental Protection Authority Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. The survey limitations are discussed in the context of the site inspection in Table 4.

Table 4. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	Desktop assessment reviewed a number of Level 1 and targeted surveys. The field surveys conducted included a range of targeted sampling for the Red-tailed Phascogale, including habitat assessments, camera trapping and searching for evidence of the species. Survey intensity was deemed adequate due to the number of surveys previously conducted for the project areas.
Competency/experience of the consultant(s) carrying out the survey.	The authors and field personnel have had extensive experience in conducting desktop reviews, habitat assessments and targeted camera trapping for significant species.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The site investigation targeted descriptions of the environment and fauna values for the Red-tailed Phascogale.
Proportion of fauna identified, recorded and/or collected.	The Red-tailed Phascogale was recorded during camera trapping surveys and further information was provided from other fauna assessments and scientific studies.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous fauna surveys in the three project areas and greater Wheatbelt region (GHD 2016a; 2016b; 2016c,Short and Hide 2012, Short *et al*. 2011) and databases (DPaW, SPRAT, BCE and ALA database), see Section 2.1.
The proportion of the task achieved and further work which might be needed.	Desktop review and field survey complete.
Timing/weather/season/cycle.	There were no constraints from the weather and conditions allowed personnel to move around readily. Camera trapping conducted in February-March 2017.
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	No disturbances affected the survey results.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was adequate to satisfy DSEWPaC (2011) guidelines.
Completeness (e.g. was relevant area fully surveyed).	The project areas were visually inspected and all major fauna habitats sampled. Habitats likely to support the Red-tailed Phascogale were subject to greater sampling and investigation.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Field personnel have extensive experience with fauna in the region.
Remoteness and/or access problems.	No remoteness and/or access problems were encountered.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

2.4 Personnel

Field personnel include:

- Dr Mike Bamford - *BSc (Biol.), Hons (Biol.), PhD (Biol.);*
- Brenden Metcalf - *BSc (Env. Sci.), Hons(Biol.); and*
- Andrew McCreery - *BSc (Env. Sci.).*

This assessment report was prepared by Cameron Everard *(BSc (Env. Sci.), MSc (Env. Mgt.)),* Brenden Metcalf and Dr Mike Bamford. Andrew Moore (BSc, BAppSc, MSc) assisted with field logistics and production of figures.

3 Desktop assessment results

This section outlines the results of the desktop assessment and includes a discussion on the regional geography which influences fauna habitat and the likelihood of the species to occur. Information from several regional studies and impact assessment reports pertinent to the project are summarised below.

3.1 Regional geography

The Interim Biogeographic Regionalisation of Australia (IBRA) (Environment Australia 2000) has identified 26 bioregions in Western Australia that are further divided into subregions (Figure 6). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995). IBRA bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA 2004).

The Toodyay-Goomalling Road (M060) is located in the Rejuvenated Drainage (AVW-02) subregion of the Avon Wheatbelt bioregion. Beecham (2001) describes the AVW-02 subregion as 'an area of active drainage dissecting a Tertiary plateau in Yilgarn Craton. It is a gently undulating landscape of low relief. The vegetation includes Proteaceous scrubheaths, rich in endemics, on residual lateritic uplands and derived sandplains; mixed eucalypt, *Allocasuarina huegeliana* and Jam-York Gum woodlands on Quaternary alluvials and eluvials. Within this, AW2 is the erosional surface of gently undulating rises to low hills with abrupt breakaways and continuous stream channels that flow in most years. Colluvial processes are active. The soil is formed in colluvium or in-situ weathered rock. The area includes woodland of Wandoo, York Gum and Salmon Gum with York Jam and Casuarina. The climate is Semi-arid (Dry) Warm Mediterranean.'

The Williams to Narrogin Highway (H053) is located in the Rejuvenated Drainage (AVW-02) subregion of the Avon Wheatbelt Bioregion and the Northern Jarrah Forest (JAF-01) subregion of the Jarrah Forest bioregion. Williams and Mitchell (2001) describe the JAF-01 subregion as a 'duricrusted plateau of Yilgarn Craton characterised by Jarrah-Marri forest on laterite gravels and, in the eastern part, by woodlands of Wandoo - Marri on clayey soils. Eluvial and alluvial deposits support Agonis shrublands. In areas of Mesozoic sediments, Jarrah forests occur in a mosaic with a variety of species-rich shrublands. The climate is 'Warm Mediterranean'. The AVW-02 subregion is described above.

The Pinjarra to Williams Road (M053) is located in the Northern Jarrah Forest (JAF-01) subregion of the Jarrah Forest bioregion; this region is discussed above.

The Red-tailed Phascogale is known to occur in the Avon Wheatbelt, Jarrah Forest, Mallee and Esperance Plains bioregions of Western Australia (Short and Hide 2012).

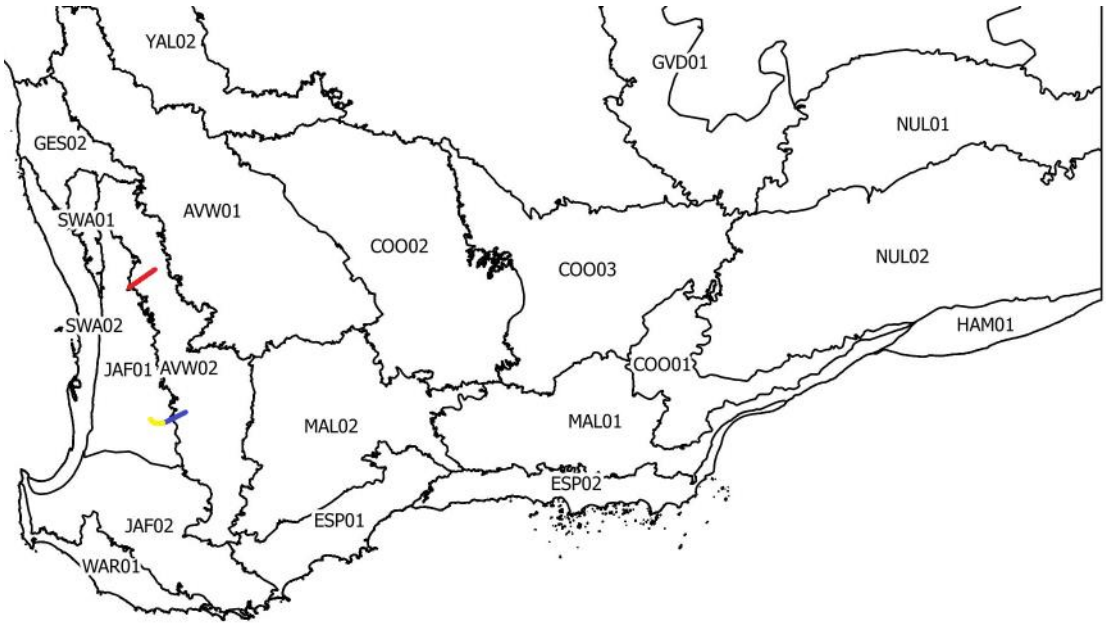

Figure 6. Location of study areas relative to the IBRA Subregions (version 7) in Western Australia. Toodyay to Goomalling – M060 (red), Pinjarra to Williams – M053 (yellow) and Williams to Narrogin – H053 (blue).

3.2 Database searches

Toodyay-Goomalling Road (MO60)

Database searches within and around the Toodyay-Goomalling Road project area did not identify any Red-tailed Phascogale records. There are some records from Mundaring and east (DPaW 2017), however the northern extent is more likely to occur further south of Mundaring near Beverley (museum record from 2000; DPAW, 2017) or Brookton (Short and Hide 2012; see Figure 9).

Pinjarra-Williams Road (M053)

Six locations were recorded from along and/or near the Pinjarra-Williams Road project area (DPaW 2017) (Figure 8).

Williams-Narrogin Highway (H053)

The species was recorded at seven locations along and near the Williams-Narrogin Highway project area (DPaW 2017) (Figure 8). Records were concentrated around the towns of Williams and Narrogin, with no records along the highway.

At a regional level, database searches identified the species in several nature reserves, state forest and private land within a 30km search radius of the southern two study area (Figure 8). No records were identified in the same search radius of the Toodyay – Goomalling study area (Figure 7).

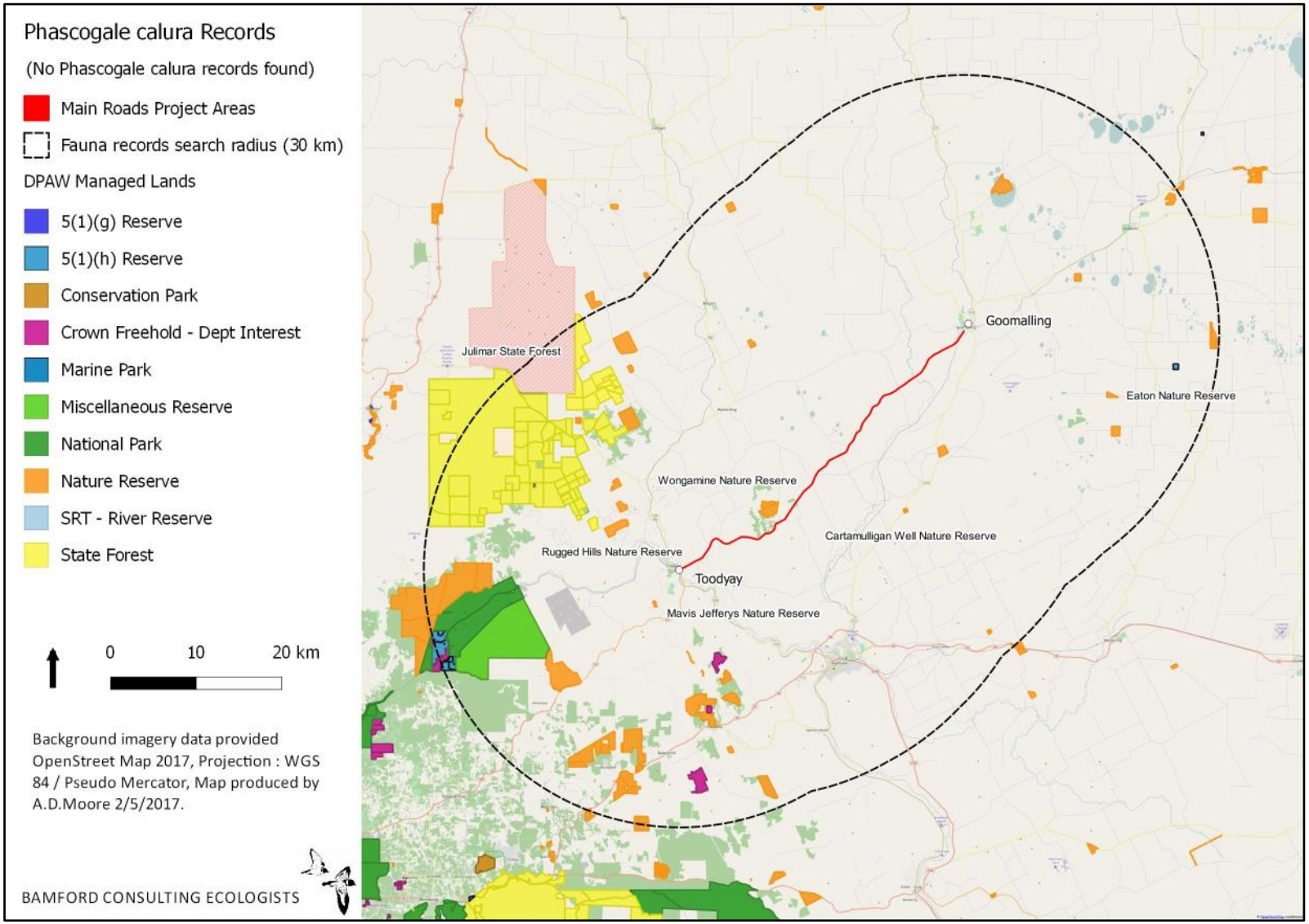

Figure 7. **Red-tailed Phascogale records within the Toodyay – Goomalling Road study area.** No Red-tailed Phascogale records within this study area.

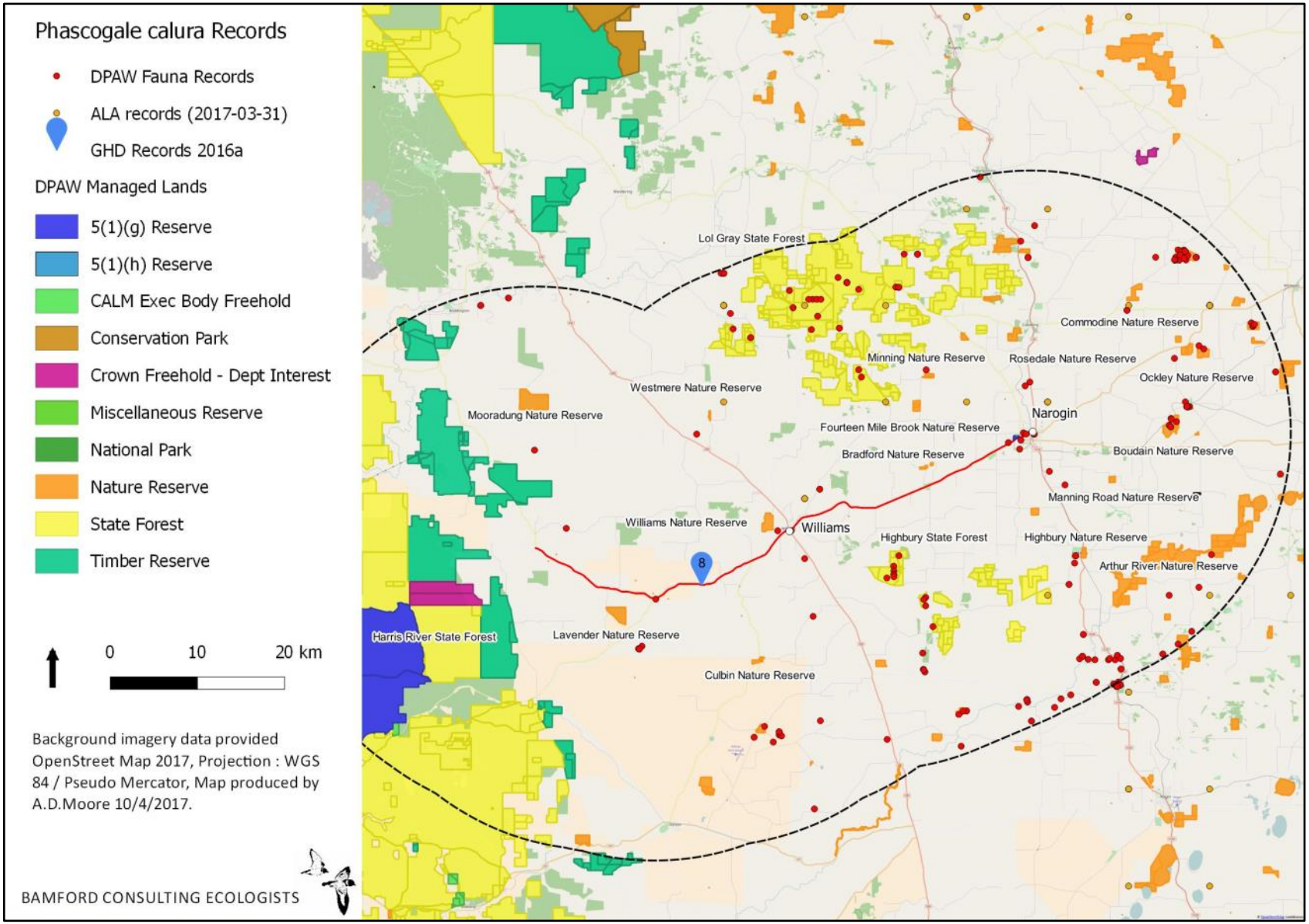

Figure 8. Red-tailed Phascogale records within the Pinjarra – Williams and Williams – Narrogin study areas.

3.3 Summary of studies

As discussed in Section 2.1.2, several studies have been conducted on the distribution and habitat of the Red-tailed Phascogale in the Wheatbelt region (Short *et al.* 2011, Short and Hide 2012). In addition, a desktop assessment and several field surveys have also been completed for the project areas (GHD 2016a; 2016b; 2016c). The key outcomes from these studies are summarised below.

Short *et al.* (2011) studied the habitat requirements of the Red-tailed Phascogale including a trapping programme south of Narrogin to Katanning and found that the species was widespread throughout this range in suitable upland habitat (*Eucalyptus wandoo* and *Allocasuarina huegeliana*) and lowland habitat (riverine vegetation of *Casuarina obesa*, *E. loxophleba* and *E. wandoo*). No trapping sites were located near (within 5-10 kms) of the project area, although the study does show that the species is widespread from the north of Wagin to Katanning. The study suggested that the area of remnant vegetation occupied by the species varied from very small (<20 ha) to very large (>200 ha) and was distributed widely across the landscape.

Short and Hide (2012) investigated the distribution and status of the Red-tailed Phascogale. The study examined the key vegetation types associated with the species and the impact of feral and domestic cats. The species is restricted to the southern wheatbelt from Brookton to Katanning and from about Williams to Dumbleyung, an area of approximately 150 km by 80 km (Figure 9), although there is a museum record from Beverley in 2000. Some records were also found to the west of this area in Jarrah (*Eucalyptus marginata*) forest and to the east to Hyden and Newdegate and south to Bremer Bay (Short and Hide 2012). Most of the records were located in the Avon Wheatbelt bioregion, but also occurred in the Jarrah Forest, Mallee and Esperance Plains bioregions (Figure 9).

Red-tailed Phascogale have been recorded at least once in 40 nature reserves and/or national parks and 19 other Crown reserves. The species is present at Dryandra and Highbury State Forests, and Yornaning, Dongolocking, Tutanning and Boundain Nature Reserves; some of these records are shown in Figure 8. It also occurs at Boyagin, Weam and Pingeculling Nature Reserves (Short and Hide 2012).

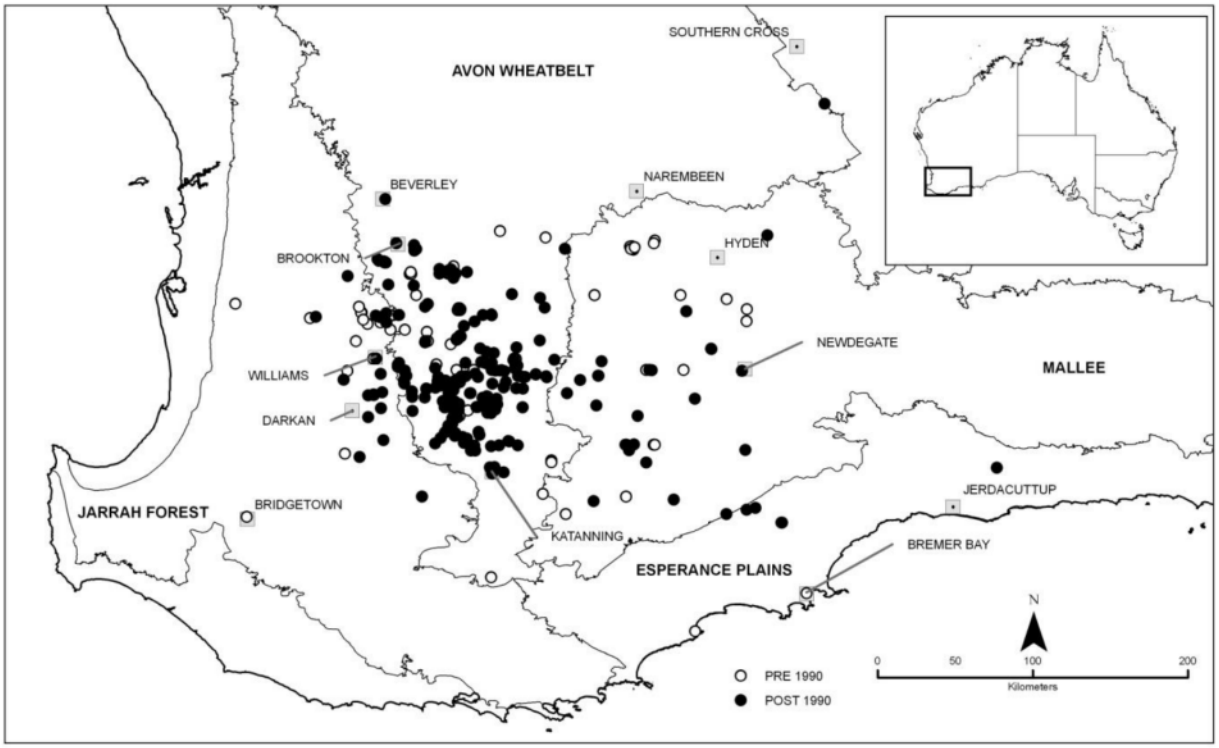

Figure 9. Red-tailed Phascogale records located in IBRA bioregions from Short and Hide (2012).

GHD surveys

A Level 1 flora and fauna survey and targeted Black-Cockatoo habitat assessment was conducted on the 9th – 13th November 2015 and 3rd December 2015 in the project area (GHD 2016a). Further follow-up surveys were undertaken on the 11th – 17th February 2016 and 3rd – 4th March 2016. These surveys focussed on assessing Black-Cockatoo habitat. Camera traps were employed within or just outside of the three project areas to target the Red-tailed Phascogale and are discussed below.

Thirteen infra-red cameras were used for 21 - 24 days between November and December 2015 (288 trap nights). Twenty species were captured on cameras including six birds, four reptiles and 10 mammals of which five were introduced. The Red-tailed Phascogale was recorded numerous times (38+) over multiple nights from two cameras (Cam 10: 50H 478751E 6338816S and Cam GHD: 50H 478839.00E 6338808S). The two cameras were located in a small area of Wandoo and Sheoak woodland within the Pinjarra-Williams Road project area (the same location as MC047 as shown in Figure 4). Records show juvenile, adult and a female with pouch young.

The species was not recorded in the Williams-Narrogin and Toodyay-Goomalling project areas, however it was considered to potentially to occur at the Williams-Narrogin Highway on the basis of records in the region and the availability of suitable habitat (Table 5). The Red-tailed Phascogale is less likely to occur within the Toodyay-Goomalling Road due to the lack of suitable habitat. There is also a small likelihood that the species would occur in the surrounding area, as the project area is outside of the species known distribution, which appears to be a line from Beverley to Hyden (Short and Hide 2012).

The area of potential Phascogale habitat (including foraging and breeding habitat) within the three project areas was investigated by GHD (2016b) and summarised in Table 5. The study found that approximately 19.39 ha of suitable habitat for the Red-tailed Phascogale would be cleared as a result of the project.

Although counts or assessments of suitable phascogale hollows was not included in the GHD study, the survey did include an assessment of suitable hollow bearing trees for Carnaby's Black-Cockatoo, including medium and smaller hollows and gives some estimation (albeit conservative) of breeding potential within the Project areas. Eighteen hollows varying from small to large were recorded at the Toodyay-Goomalling project area. No hollows were recorded along the Williams-Narrogin Highway and six hollows at the Pinjarra-Williams Road (GHD 2016b).

As noted in Section 2.2.2, vegetation type can be used as a surrogate for tree hollow availability, with vegetation types containing Wandoo the most prospective. In the three areas investigated, areas of vegetation containing Wandoo were (see Table 5): Toodyay-Goomalling Road – 0.21ha; Williams-Narrogin Highway – 0.64ha; and Pinjarra-Williams Road – 2.70ha.

Table 5. Summary of Red-tailed Phascogale habitat recorded in the project area, based on GHD (2016b).

Project area	Habitat types present (area in ha)	Total area of RTP habitat in ha[2]	Recorded (likelihood)
Toodyay-Goomalling Road (M060)	Wandoo woodland (0.21) Wandoo/Allocasuarina shrubland (0) Mixed Eucalyptus woodland (4.94) Low shrubland (0.35) Rivers, creeks and drainage lines (0.91) Planted shrub species (0) Cleared/disturbed area (31.03)	6.41	No (Low) 21.41
Williams-Narrogin Highway (H053)	Wandoo woodland (0.56) Wandoo/Allocasuarina shrubland (0.08) Mixed Eucalyptus woodland (1.66) Low shrubland (0.37) Rivers, creeks and drainage lines (0.062) Planted shrub species (2.79) Cleared/disturbed area (19.6)	5.52	No (High) 15.06
Pinjarra-Williams Road (M053)	Wandoo woodland (1.44) Wandoo/Allocasuarina shrubland (1.26) Mixed Eucalyptus woodland (0.6) Low shrubland (1.66) Rivers, creeks and drainage lines (1.32) Planted shrub species (1.18) Cleared/disturbed area (19.12)	7.46	Yes (Recorded in Wandoo and Sheoak shrubland) 19.05
	Total:	19.39	

[2]Area excludes cleared and disturbed areas. Based on GHD (2016b).

4 Field survey results

4.1 Toodyay-Goomalling Road (M060)

Nine cameras were deployed along the Toodyay-Goomalling Road, although due to technical issues with four cameras only five recorded images. Eight vertebrate fauna species were recorded, including four native birds, one native mammal and three introduced mammals (detailed in Table 6); no Red-tailed Phascogale were recorded from this study area. The Toodyay-Goomalling Road supported very little Wandoo, but the reserve where the cameras were set was dominated by Wandoo open woodland and was thus considered to be the most likely location in the area to support Red-tailed Phascogales if the species is still present in the vicinity. The lack of records from this reserve supports the conclusion by Short and Hide (2012) that the Red-tailed Phascogale no longer occurs in the north of its former range.

Table 6. Fauna Records from cameras along the Toodyay-Goomalling Road. Camera names crossed out are those that did not record any data due to technical issues.

Camera	Fauna Species								
	STUBBLE QUAIL	COMMON BRONZEWING	AUSTRALIAN RAVEN	WHITE-BROWED BABBLER	ECHIDNA	EUROPEAN RABBIT	RED FOX	CAT	HOUSE MOUSE
Goo1	1	1				1			
Goo2									93
~~Goo3~~									
Goo4			1		2			4	86
Goo5			1	1					
~~Goo6~~									
~~Goo7~~									
Goo8		1					5		
~~Goo9~~									

4.2 Williams-Narrogin Highway (H053)

Sixteen cameras were deployed along the Williams-Narrogin Highway. Fourteen vertebrate fauna species were recorded including five birds, five native mammals and four introduced mammals (detailed in

Table 7); Red-tailed Phascogale were recorded from five locations (location shown in Figure 10; Plate 1 and Plate 2 show photos from two of these locations). These locations were widespread along the alignment. While the Williams-Narrogin Highway has only a small area of vegetation containing Wandoo, it does lie just south of the Dryandra area (state forest on Figure 10) where there are many records of Red-tailed Phascogales. There are also smaller areas of state forest with Red-tailed Phascogale records to the south, so this section of road may be passing through a region where the species regularly moves across the landscape between large populations.

Table 7. Fauna Records from cameras along the Williams-Narrogin Highway.

Camera	Fauna Species														
	Rufous Treecreeper	Common Bronzewing	Australian Raven	Australian Owlet Nightjar	Grey Shrike-thrush	New Holland Honeyeater	Red-tailed Phascogale	Little Long-tailed Dunnart	Brush-tailed Possum	Western Grey Kangaroo	Echidna	Cat	Red Fox	House Mouse	Black Rat
MC41			1						3		1		2	1	4
MC42														1	11
MC43				1			1		6				2		44
MC44								1	3				4	2	
MC45					1		20							136	1
MC46					1		14							7	13
MC51							3		22	2	1				
MC52												1			
MC53													2		
MC54												1	1	1	1
MC55		2				1							2	80	6
MC56	5													13	
MC57							1						1		
MC58	24	1							8					13	3
MC59													1	13	
MC60															101

4.3 Pinjarra-Williams Road (M053)

Four cameras were deployed along the Pinjarra-Williams Road. Seven species were recorded including three native mammals and four introduced mammals (detailed in Table 8); Red-tailed Phascogale were recorded from one location (location shown in Figure 10; Plate 3 shows a photo from this location). Although the Pinjarra-Williams Road has a large area of vegetation containing Wandoo, it is not as close to large reserve system where the species is regularly recorded as is the Williams-Narrogin Road.

Table 8. Fauna Records from cameras along the Pinjarra-Williams Road.

Camera	Fauna Species						
	Red-tailed Phascogale	Brush-tailed Possum	Western Grey Kangaroo	Cat	Red Fox	House Mouse	Black Rat
MC47	1	20		2		1	2
MC48				4	8		
MC49		7	1	1	1	4	2
MC50		3	1		13		8

4.4 Summary of Results

Red-tailed Phascogale were recorded from five locations within the Williams-Narrogin Highway study area and one location in the Pinjarra-Williams Road study area, as shown in Figure 10, Figure 11, and detailed in Table 9**Error! Reference source not found.**. The highest level of activity was recorded in a Wandoo/Allocasuarina Woodland remnant approximately 6.5km east of Williams, where two cameras (MC045 and MC046) were placed ~200m apart and recorded 34 events of Red-tailed Phascogale. Of the locations where Red-tailed Phascogale were recorded, this was the smallest remnant/reserve, consisting only of a narrow strip of vegetation parallel to the Williams – Narrogin Highway. , with the clearing areas presented in Table 9 estimated by scanning and digitising what appeared to be remnant vegetation within the clearing zone on maps provided by Main Roads. The total area of clearing in these sectors is 1.28 ha compared with a total reserve size of 1134 ha.

Table 9. Summary of Red-tailed Phascogale results recorded on camera.

Project Area	Camera Number	Approximate Reserve/Remnant size [3]	Approximate area to be directly impacted	Vegetation type at Camera location	No. of Phascogale records
Williams – Narrogin Highway	MC043	41 ha	<0.09 ha	Wandoo/Allocasuarina Woodland	1
	MC045	35 ha	<0.07 ha	Wandoo/Allocasuarina Woodland (burnt within 10 years)	20
	MC046				14
	MC051	608 ha	<0.84 ha	Wandoo/Allocasuarina Woodland	3
	MC057			Mixed Eucalypt	1
Pinjarra – Williams Road	MC047 [4]	450 ha	<0.28 ha	Wandoo/Allocasuarina Woodland	1

[3] These measurements are very approximate and generally include areas of woodland/shrubland vegetation bordered by major roads, housing, open paddocks. Most remnants were linked to other areas via vegetation corridors and in some cases formed part of a larger bushland area dissected by major roads

[4] This was the same location where GHD (2016a) had recorded Red-tailed Phascogales previously.

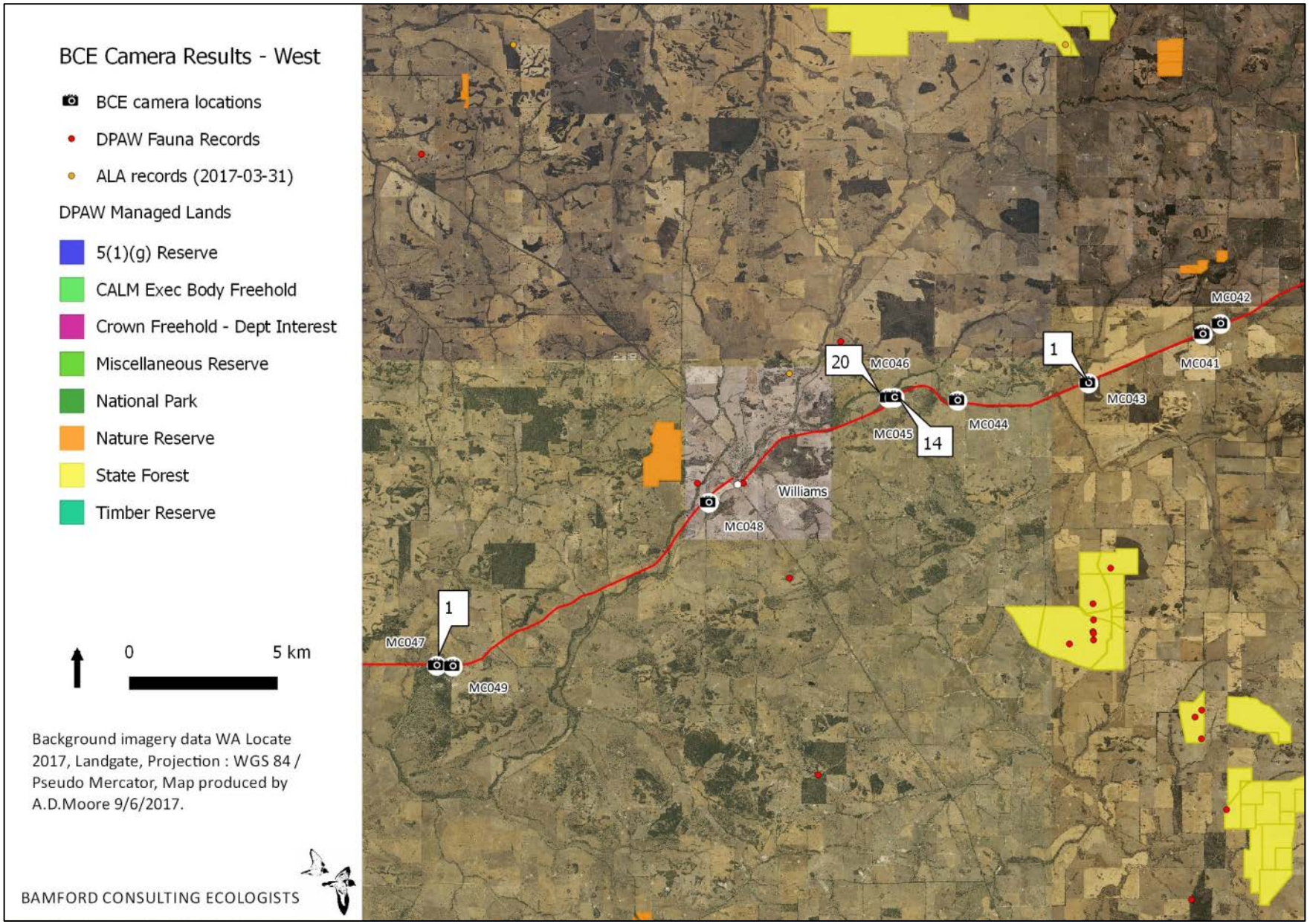

Figure 10. **Location of Red-tailed Phascogale records from this study;** numbers refer to the recorded events at each location**.**

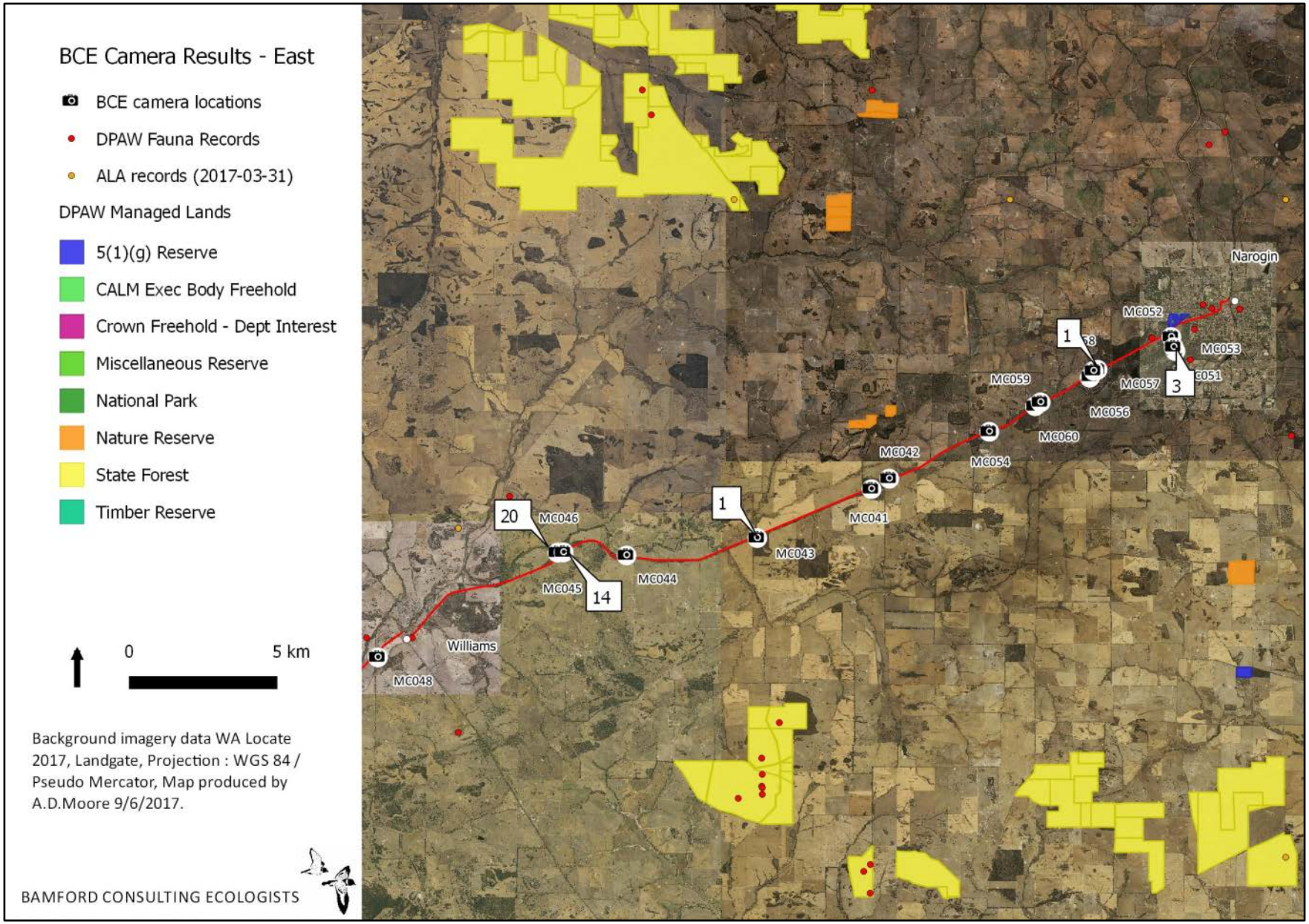

Figure 11 Location of Red-tailed Phascogale records from this study (east map); numbers refer to the recorded events at each location.

Plate 1. **Red-tailed Phascogale photo taken at MC51, within the Williams-Narrogin Highway study area.**

Plate 2. **Red-tailed Phascogale photo taken at MC46, within the Williams-Narrogin Highway study area.**

Plate 3. Red-tailed Phascogale photo taken at MC47, within the Pinjarra – Williams Road study area. This is the same location, within 30-100 metres, where GHD recorded Red-tailed Phascogale previously.

5 Discussion

This assessment confirmed the presence of Red-tailed Phascogale at five locations in the Williams - Narrogin Highway (H053) study area and one location in the Pinjarra – Williams Road study area (M053). The species would almost certainly utilise other areas of remnant vegetation or revegetated areas within these two study areas. The Toodyay-Goomalling Road study area is outside the Red-tailed Phascogale's currently known distribution and the lack of camera records from this study area was thus not an unexpected outcome. The high level of recording along the Williams – Narrogin Highway may be because this section of road lies between two fragmented regions of state forest where there are many records of the species and apparently a thriving population. The abundance of the species along this section of road may be due to its location in relation to existing populations rather than just as a result of site characteristics. For example, the Pinjarra – Williams road section has a larger area of Wandoo woodland but fewer phascogale records.

The six camera locations where Red-tailed Phascogale were recorded were in remnant/revegetated areas varying in size between 35 – 680ha (see Figure 10 and Figure 11). Short and Hide (2012) assessed the size distribution of reserves with Red-tailed Phascogales and found it to be strongly skewed to small reserves (<500ha) with most records in reserves of less than 250ha. They suggest "it is likely that the species' ongoing persistence will depend on their survival in small reserves. This is likely to require effective dispersal between reserves and between reserves and nearby remnant vegetation". This highlights the benefit of vegetation corridors that allow the easy movement of the Red-tailed Phascogale through the landscape.

An assessment of vegetation/habitat within the study areas (as taken from GHD, 2016b; shown in Table 10) shows 14.71 ha and 15.06 ha of remnant vegetation/revegetation is likely to be impacted by the proposals in the Pinjarra-Williams Road study area and the Williams – Narrogin Highway study area respectively; a total of 29.77 ha across both of the southern study areas. This includes 7.15ha of vegetation containing Wandoo, the most important tree for the provision of hollows, with 2.68ha in the important Williams - Narrogin sector. These are almost certainly over-estimates and calculation of revised clearing areas at locations where the species was recorded in the current study (Table 9) gives an estimate of <1.28 ha. This is not for the entire road, but is for key areas where Red-tailed Phascogales were recorded. Clearing is of most concern where it impacts narrow corridors of vegetation along road verges that would act as corridors facilitating the movement of fauna through the landscape, including the Red-tailed Phascogale. However, Main Roads advises that where vegetation along verges will be impacted, the majority of verge vegetation will be retained and the corridor will be narrowed by the loss of only the first line of trees. Main Roads has also advised that very little clearing will be required in the sectors where Red-tailed Phascogales were recorded (see Table 9).

The potential loss of tree hollows within the proposed maintenance zone will vary in significance depending on their location relative to other tree hollows. Isolated hollows potentially provide occasional nesting sites for phascogales moving through the landscape and their loss therefore has the potential to limit this ability to move through the landscape. With a larger range of hollows available within larger remnants and reserves, the loss of a portion of these from the current proposal is likely to be less significant than the loss of isolated hollows. Even individual Wandoo trees along road verges could be significant.

Short *et al.* (2011) found that a lack of vegetation corridors negatively impacted the ability of the Red-tailed Phascogale to colonise and/or maintain viable populations in isolated reserves and identified "the increasing loss of corridors of vegetation along roadsides due to the widening of roads" as one of the factors contributing to "a loss of habitat and habitat connectivity". Maintaining landscape connectivity is clearly important for the species. There may be potential to enhance cover along road verges through revegetation to offset the effect of clearing along the edges of narrow verges.

Table 10. Summary of known/potential Red-tailed Phascogale habitat likely to be impacted within the Study areas.

(Table from raw data taken from GHD, 2016b)

Habitat Type	Pinjarra to Williams Road Study area	Williams to Narrogin Highway Study area
Wandoo Forest	4.47ha	2.68 ha
Flooded Gum Forest	-	3.22 ha
Marri Forest	0.99 ha	0.44 ha
Sheoak Forest	2.64 ha	0.35 ha
Jam (*Acacia acuminata*) Shrubland	3.63 ha	1.20 ha
Planted Trees	2.78 ha	7.11 ha
Scattered Native Shrubland/Woodland	-	0.06 ha
York Gum Forest	0.20 ha	-
TOTAL	**14.71 ha**	**15.06 ha**

6 References

Atlas of Living Australia (ALA) (2017). Atlas of Living Australia Database. Accessed February 2017 at: www.ala.org.au

Beecham, B. (2001). Avon Wheatbelt 2 (AW2 - Re-juvenated Drainage subregion). Department of Conservation and Land Management.

Bradley, A.J. (1997). Reproduction and life history in the red-tailed phascogale, *Phascogale calura* (Marsupialia: Dasyuridae): the adaptive-stress senescence hypothesis. Journal of Zoology 241:739-755.

Department of Environment and Conservation (DEC) (no date). Draft species Conservation Management Plan. Red-tailed Phascogale (*Phascogale calura*) Conservation Plan for the Wheatbelt Populations 2009-2014. Accessed in February 2017 at: https://www.wheatbeltnrm.org.au/sites/default/files/knowledge_hub/documents/Red-Tailed-Phascogale-Plan.pdf

Department of the Environment (2013). Matters of National Environmental Significance. Significant Impact guidelines. Department of the Environment, Canberra, Australian Capital Territory.

Department of the Environment and Energy (DoEE) (2017). Species Profile and Threats Database (SPRAT); *Phascogale calura* — Red-tailedPhascogale. Accessed February 2017 at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=316

Department of Parks and Wildlife (DPaW) (2017). NatureMap Database. Accessed February 2017 at: http://naturemap.dec.wa.gov.au/default.aspx

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2011). Survey guidelines for Australia's threatened mammals. Guidelines for detecting mammals listed as threatened under the EPBC Act. Accessed February 2017 at:https://www.environment.gov.au/resource/survey-guidelines-australias-threatened-mammals-guidelines-detecting-mammals-listed

Environment Australia. (2000). Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report. Environment Australia, Department of Environment and Heritage, Canberra, Australian Capital Territory.

Environmental Protection Authority (EPA) (2004). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.

Foster, W.K., Bradley, A.J., Caton, W. and Taggart, D.A. (2006). Comparison of growth and development of the red-tailed phascogale (*Phascogale calura*) in three captive colonies. Australian Journal of Zoology. 54:343-352.

Friend, T. (2008). *Phascogale calura*. The IUCN Red List of Threatened Species 2008: e.T16888A6544803. Accessed February 2017 at: http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T16888A6544803.en.

Friend, J.A. and Scanlon, M.D. (1996). An assessment of the effect of fox control on populations of the red-tailed phascogale: Phase 4: Final report. Department of Conservation and Land Management Feral pests program project 18. Perth, Department of Conservation and Land Management.

GHD (2016a). Maintenance Zone Establishment - Toodyay Goomalling Road (MO60), Williams Narrogin Highway (H053) and Pinjarra Williams Road (M053) - Biological Survey. Report prepared for Main Roads Western Australia, April 2016.

GHD (2016b). Maintenance Zone Establishment - Toodyay Goomalling Road (MO60), Williams Narrogin Highway (H053) and Pinjarra Williams Road (M053) – EIA and EMP. Report prepared for Main Roads Western Australia, April 2016.

GHD (2016c). Maintenance Zone Establishment - Toodyay Goomalling Road (MO60), Williams Narrogin Highway (H053) and Pinjarra Williams Road (M053) – Impact Assessment of Clearing. Report prepared for Main Roads Western Australia, August 2016.

Kitchener, D. (1981). Breeding, diet and habitat preference of *Phascogale calura* (Gould 1844) (Marsupalia: Dasyuridae) in the southern wheatbelt, Western Australia. Records of the Western Australian Museum 9(2), 173-186.

Maxwell, S., Burbidge, A. and Morris, K. (1996). The 1996 Action Plan for Australian Marsupials and Monotremes. Wildlife Australia, Environment Australia. Accessed February 2017 at: http://www.environment.gov.au/resource/action-plan-australian-marsupials-and-monotremes.

McKenzie, N. L., May, J. E. and McKenna, S. (2003). Bioregional Summary of the 2002 Biodiversity Audit for Western Australia., The National Land and Water Resources Audit, Western Australian Department of Conservation and Land Management, Perth, Western Australia.

Short, J. and Hide, A. (2012). Distribution and status of the red-tailed phascogale (*Phascogale calura*). Australian Mammalogy, 34 (1). pp. 88-99.

Short, J., Hide, A. and Stone, M. (2011). Habitat requirements of the endangered red-tailed phascogale,(*Phascogale calura*). Wildlife Research, 38 (5). pp. 359-369.

Thackway, R., and Cresswell, I. (1995). An interim biogeographic regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative. Australian Nature Conservation Agency, Reserve Systems Unit.

Van Dyck, S. and Strahan, R. (Eds.) (2008). Mammals of Australia. 3rd Edition. Australian Museum, Sydney.

Whitford, K. (2001). Dimensions of tree hollows used by birds and mammals in the jarrah forest: improving the dimensional description of potentially usable hollows. *CALMScience* **3**(4): 499-511.

Whitford K. (2002). Hollows in Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) trees. I. Hollow sizes, tree attributes and ages. *Forest Ecology and Management* 160: 201-214.

Williams, K. and Mitchell, D. (2001). Jarrah Forest 1 (JF1 – Northern Jarrah Forest subregion). Department of Conservation and Land Management.

7 Appendices

Appendix 1. GPS Coordinates for each camera location.

Project area and camera number	Zone	Easting	Northing
Toodyay-Goomalling Road			
GOO01	50 J	477995	6531587
GOO02	50 J	477953	6531564
GOO03	50 J	477916	6531602
GOO04	50 J	477885	6531556
GOO05	50 J	459486	6515576
GOO06	50 J	459552	6515287
GOO07	50 J	459993	6515182
GOO08	50 J	459940	6515118
GOO09	50 J	460516	6515021
Williams-Narrogin Highway			
MC041	50 H	504653	6350031
MC042	50 H	505256	6350382
MC043	50 H	500784	6348381
MC044	50 H	496356	6347794
MC045	50 H	494017	6347888
MC046	50 H	494223	6347896
MC051	50 H	514956	6354676
MC052	50 H	514820	6355149
MC053	50 H	514901	6354809
MC054	50 H	508646	6351962
MC055	50 H	512053	6353783
MC056	50 H	512077	6353817
MC057	50 H	512318	6354049
MC058	50 H	512184	6354010
MC059	50 H	510201	6352822
MC060	50 H	510386	6352953
Pinjarra-Williams Road			
MC047	50 H	478745	6338853
MC048	50 H	487940	6344353
MC049	50 H	479290	6338828
MC050	50 H	473697	6337176