



Woolgoolga to Ballina Pacific Highway Upgrade

Rufous Bettong Construction Monitoring for Sections 1 & 2: Year 1

February 2017



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Executive Summary

Year 1 monitoring for Rufous Bettong (*Aepyprymnus rufescens*) was performed in a manner consistent with the Threatened Mammal Management Plan Version 2.1 up until October 2015 and later 3.1 (RMS 2015). Only the two sites located in Section 2 (Sites 1 and 2) of the Woolgoolga to Ballina Upgrade could be monitored so as to reflect the areas of the Project where construction had commenced. Monitoring was comprised of winter sampling performed in August 2015 followed by a summer survey in February 2016.

Bettong were recorded at Site 1A (23125) but not at the adjacent control Site 1B located 3 km to the east in Yuraygir State Conservation Area. The record of Bettong from Site 1A was the result of road kill monitoring surveys with an adult recorded from ch. 23600 (Pacific Highway near Parker Road) in mid July with a sign posted speed limit of 80 kmph. A second Bettong was recorded as road kill near Bald Knob Tick Gate Road in mid-February 2016 whilst a third individual was recorded in September 2015, between the two monitoring events. No Bettong were recorded using cameras at Site 1A, a decline, down from the 1.4% recorded in the baseline survey to 0% in Year 1. Spotlighting and nocturnal drive transects recorded no Bettong which accords with the results for the baseline survey.

Bettong were recorded at Site 2A (27420) with a mean activity rate of 9.69% and Site 2B with a mean activity rate of 27.78% located further to the north-west in Glenugie State Forest. Both the impact (2A) and control (2B) treatments recorded increases in Bettong activity, with 2A increasing from 8.5% to 9.69% and 2B from 26.4% to 29.17%, an increase of 1.19% and 2.77% respectively in Year 1. Spotlighting and nocturnal drive transects recorded no Bettong which accords with the results for the baseline survey. No Bettong were recorded as road kill in the vicinity of either treatment for Site 2.

Some changes in exotic predator activity were recorded between the baseline survey and Year 1 monitoring. Wild Dog activity has increased at both Site 1 and Site 2 with levels at Site 2 approaching a fivefold increase from the baseline survey. Red Fox remains largely absent from the monitoring sites, which in itself probably reflects competitive and predatory interactions with Wild Dog. Feral Pig was recorded for the first time at Site 1A whilst there were some small measurable changes associated to Feral Cat activity.

The implications of the findings and how these compare with performance measures outlined in the Threatened Mammal Management Plan (RMS 2015) are discussed.

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1.0 Introduction

1.1 Background

The Woolgoolga to Ballina Pacific Highway Upgrade comprises approximately 155 km of highway to achieve a four-lane divided road extending north of Woolgoolga at the northern extent of Sapphire to Woolgoolga Upgrade to south of Ballina where it ties into the southern extent of the Ballina bypass. The project includes grade separated interchanges, service roads and upgrades to local road connections and has the potential to be staged in 11 sections. The State Minister for Planning and Environment approved the project on 24th June 2014. On 14th August 2014, the Federal Minister for the Environment Greg Hunt approved the project in accordance with Part 9 of the *Environmental Protection and Biodiversity Conservation Act* (1999).

In order to enable commencement of construction in mid-2015, some key preconstruction survey tasks were to be undertaken as a priority. During preconstruction, baseline and targeted surveys of threatened species will enable the establishment of the monitoring program to be implemented on an ongoing basis to help manage and mitigate any potential impacts of the project on threatened species. Requirements for monitoring and mitigation measures throughout various stages of the project are outlined in a series of threatened species management plans.

The Threatened Mammal Management Plan developed for the Upgrade addresses the impacts of the road and proposes mitigation on a number of threatened ground dwelling mammal species including the Rufous Bettong, Spotted-tailed Quoll, Brush-tailed Phascogale and Long-nosed Potoroo (RMS 2015). One component of this plan was to perform Bettong monitoring during the construction of the Upgrade in the same manner as the preconstruction baseline surveys which had been performed in 2014 (Lewis 2014). Consequently, the Roads and Maritime Services (RMS) engaged Lewis Ecological Surveys (Contract Identifier – 13.2544.0919-0020) on the 17th August 2015 to implement Year 1 during construction surveys which is comprised of a winter and summer survey. The following details the winter monitoring event in Section 2 where two paired monitoring sites (1A, 1B and 2A, 2B) are located (Figure 1-1).



Plate 1-1. Rufous Bettong.

1.2 Subject Species – Rufous Bettong

1.2.1 Description

The Rufous Bettong (*Aepyprymnus rufescens*) is a small marsupial measuring 70 to 80 cm in length from nose to tail. They have reddish-brown fur which extends onto the muzzle (Plate 1-1). They normally move quite slowly by placing the forelegs on the ground and bringing their hind legs forward together, but can also hop like a kangaroo (OEH 2014).



Figure 1-1. Distribution of paired BACI sites in relation to the W2B Upgrade corridor.

1.2.2 Distribution

Historically known from Coen in north Queensland to central Victoria with this range now contracted from Cooktown in Queensland to north-eastern NSW as far south as Mt Royal National Park. In NSW, the Rufous Bettong has largely vanished from inland areas apart from some sporadic and unconfirmed records in the Pilliga and Torrington districts (OEH 2014). In coastal NSW, the species is reasonably common inhabitant of the coastal forests and woodlands in the lower Clarence Catchment north from Kungala to about Tyndale and extends west to the Nymboida, Jackadgery and Drake areas (Bionet Wildlife Atlas 2016).

1.2.3 Habitat and Ecology

Bettong inhabit a variety of forests from tall, moist eucalypt forest to open woodland, with a tussock grass understorey (OEH 2014). A dense cover of tall native grasses is the preferred shelter. They sleep during the day in cone-shaped nests constructed of grass in a shallow depression at the base of a tussock or fallen log. At night they feed on grasses, herbs, seeds, flowers, roots, tubers, fungi and occasionally insects (OEH 2014).

1.2.4 Conservation Status

In NSW, the Rufous Bettong is currently listed as Vulnerable pursuant to the NSW *Threatened Species Conservation Act* (1995). It is not currently listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* (1999).

2.0 SURVEY METHODS

2.1 Monitoring Sites

All monitoring sites occur within Section 2 of the Upgrade works and whilst Section 1 is also under construction there is no current evidence to suggest Bettong inhabit areas within or in close proximity to that area (OEH 2016; Lewis 2015). Within Section 2, there are two paired sampling sites referred to as Site 1A, 1B, 2A and 2B with summary descriptions provided in Table 2-1. This sampling design known as a BACI (Before-After-Control-Impact) consists of the following:

- Impact sites which are identified in this instance with an ‘A’ and may be potentially impacted by construction works or once the newly constructed carriageway is completed. Potential impacts may include but are not necessarily limited to habitat removal, a reduction in habitat connectivity, facilitating the distribution and increasing densities of exotic predators and creating hazards such as increased road strike;
- Reference or control sites which are identified in this instance with an ‘B’ and possess similar geographic landscape and habitat traits as the impact sites but are located a sufficient distance from the Upgrade. In the case of the Bettong, this is thought to be around 2 km as individuals may occupy home ranges of approximately 20 ha and nightly movement of up to 625 m (Claridge *et al.* 2007).

Table 2-1. Preconstruction baseline monitoring sites for Bettong.

Paired Monitoring Site	Impact	Control/Reference	Comment & Status of Construction Activities
Bettong – Camera Traps, Spotlighting, Nocturnal Drive Transects			
1 (Section 2)	Site 1A - CH23125 dedicated culvert 2.4 x 3, 22m long.	Site 1B - 3 km to the east and south of Bald Knob Tick Gate Road	<ul style="list-style-type: none"> • Bettong observed as road kill at Site 1A in <i>circa</i> 2010. • Site partially cleared at time of survey for erosion and sediment control and associated access (Stage 1 clearing). Mainline or Stage II clearing completed just prior to summer survey. • The control site contains similar habitat types and Bettong have previously been observed adjacent to the grid.
2 (Section 2)	Site 2A - CH27420 combined culvert 3.6 x 2.4, 104m long.	Site 2B - 3.6 km to the north west towards Braunstone in Glenugie State Forest	<ul style="list-style-type: none"> • Some variation in habitat type and suitability between the eastern and western side. Eastern side is a higher use area than the western side. • Stage I and II mainline clearing in past 4 weeks or just prior to the winter survey. • Reported as a road kill hotspot.

2.2 Sampling Regime

2.2.1 Camera Trapping

At each site, 36 camera traps (Scoutguard 560 k zero glow) were installed across a 600 m grid (36 ha) with 100 m trap spacing and left operating over a continuous 14 night period (504 nights effort) for each of the two seasons. The specific dates are as follows:

- Winter Sampling between the 18-20th August and the 1-3rd September 2015.

- Summer sampling between the 11th and 29th February 2016 (Table 2-2).

At each site, cameras were installed using the following recording parameters:

- Timer mode set from dusk (1700 hrs) till dawn (0700 hrs);
- Sensitivity mode was set to 'high' and where required, vegetation such as long grass was trimmed to reduce false trigger events (i.e. grass being blown in the wind);
- Each triggering event recorded two still images set in 8 mb file size;
- Reset time interval for retriggering was set at 30 seconds.

Each camera trap was baited using one large handful of peanut butter, honey and oats bait with added natural vanilla extract (Queen Brand). The bait was scattered over an area of 4-9 m² and the earth was partly disturbed to increase the likelihood of the area being visited by the target species. Cameras were generally fixed to a tree or stump in a horizontal facing position around 1 m off the ground with the primary objective of obtaining the largest field of view possible. The positioning of cameras was guided by recent field survey evaluations of camera trap orientation whilst surveying for other small macropods and potoroids (see Taylor *et al.* 2013).

All camera images were downloaded onto a desktop computer for viewing on a 20 inch screen with each image viewed and the animal identified by BL (Ben Lewis). All images were identified to species level apart from *Antechinus* and Rodents that were retained in these two groups. Threatened species records were forwarded to the *Roads and Maritime* for distribution into other monitoring programs.

Table 2-2. Summary of the installation and retrieval time periods for camera trap monitoring at Bettong sites.

Survey Period	Site	Installation Date	Retrieval Date	No. Nights	No. Cameras Retrieved	Effort (Camera Trap Nights)
Winter	Site 1A Impact	18.08.2015	01.09.2015	14	36	504
Winter	Site 1B Reference	18.08.2015	01.09.2015	14	36	504
Winter	Site 2A Impact	19.08.2015	02.09.2015	14	36	504
Winter	Site 2B Reference	20.08.2015	03.09.2015	14	36	504
Summer	Site 1A Impact	15.02.2016	29.02.2016	14	36	504
Summer	Site 1B Reference	15.02.2016	29.02.2016	14	36	504
Summer	Site 2A Impact	15.02.2016	29.02.2016	14	36	504
Summer	Site 2B Reference	15.02.2016	29.02.2016	14	36	504
					Total	4032 trap nights

2.2.2 Spotlighting

Spotlighting was undertaken at all sites over two non-consecutive nights in each season (Table 2-3). Each spotlight transect lasted 1 person hour (2 person hours per site) and involved walking systematically through the 600 m grid using a 800 lumen head torch. The number of positively identified Bettong were recorded.

Table 2-3. Summary of the spotlight surveys at each site.

W2B Section	Site	Spotlight 1	Spotlight 2	Effort (Person Hours)	Nocturnal Drive Transect
2	Site 1A Impact	19.08.2015	02.09.2015	2	2 km north and south of the site on the Pacific Highway on each spotlight night
2	Site 1B Reference	19.08.2015	02.09.2015	2	2 km either side but on adjacent Bald Knob Tick Gate Road on each spotlight night
2	Site 2A Impact	19.08.2015	02.09.2015	2	2 km either side using access track running parallel to existing Pacific Highway. Northern extent turns east onto Franklins Road on each spotlight night
2	Site 2B Reference	19.08.2015	02.09.2015	2	3 km south east of site terminating at the northern extent of the grid on each spotlight night
2	Site 1A Impact	11.02.2016	15.02.2016	2	2 km north and south of the site on the Pacific Highway on each spotlight night
2	Site 1B Reference	11.02.2016	15.02.2016	2	2 km either side but on adjacent Bald Knob Tick Gate Road on each spotlight night
2	Site 2A Impact	10.02.2016	25.02.2016	2	2 km either side using access track running parallel to existing Pacific Highway. Northern extent turns east onto Franklins Road on each spotlight night
2	Site 2B Reference	10.02.2016	25.02.2016	2	3 km south east of site terminating at the northern extent of the grid on each spotlight night
				8 hours	

2.2.3 Nocturnal Drive Transects

Nocturnal drive transects were performed whilst commuting between the survey sites for distances of usually 2-3 km either side of the grid (Table 2-3). During this time, the vehicle was driven at speeds commensurate to the road or area being traversed. For example, narrow single lane tracks (e.g. Site 2B) were traversed at speeds of up to 20 kmph whilst an unsealed road was sampled at between 20-40 kmph (e.g. Site 1B). Sealed roads were driven at speeds of between 60-80 kmph (Site 1A Pacific Highway). The objective of this was to sample Bettong in a way that was commensurate to other road users and vehicle/Bettong interactions. All Bettong observed during these surveys were recorded and their behaviour was documented.

2.2.4 Road Kill Surveys

Road kill surveys were undertaken opportunistically during the field survey program. Importantly, surveys were conducted over 25 days with 11 surveys performed in winter merging into early spring and 14 surveys spanning from mid summer into early autumn. During each survey, the roadway was scanned for any road killed Bettong along with survey effort (distance travelled). Typically, the vehicle was driven at speeds of 60-90 kmph (i.e. depending on traffic) to inspect for all dead wildlife (road kill) on the carriageway or within 3 m of the road verge. Once road kill Bettong had been observed, a closer inspection of the carcass was undertaken to identify the age, sex and whether any pouch young were present.

Table 2-4. Summary of road kill surveys performed during the preconstruction baseline survey.

Date	Road Kill Surveys - Distance Travelled (KM)	W2B Section
Winter Construction Survey-Year 1		
04.07.2015	7	Section 2
08.07.2015	7	Section 2
11.07.2015	7	Section 2
24.07.2015	7	Section 2
25.07.2015	7	Section 2
18.08.2015	9	Section 2
19.08.2015	9	Section 2
20.08.2015	12	Section 2
01.09.2015	10	Section 2
02.09.2015	8	Section 2
03.09.2015	7	Section 2
Summer Construction Survey-Year 1		
12.01.2016	7	Section 2
13.01.2016	7	Section 2
02.02.2016	7	Section 2
05.02.2016	7	Section 2
11.02.2016	10	Section 2
13.02.2016	7	Section 2
16.02.2016	7	Section 2
20.02.2016	7	Section 2
23.02.2016	7	Section 2
25.02.2016	10	Section 2
29.02.2016	10	Section 2
01.03.2016	7	Section 2
03.03.2016	7	Section 2
07.03.2016	7	Section 2
Total	197	Section 2

2.3 Data Summaries and Statistical Analysis

2.3.1 Camera Traps

The camera trap data is reported as the mean activity level or rate derived from the number of cameras that detected Bettong and was reported for each of the two survey periods (i.e. Survey 1 and Survey 2). For example, images of Bettong recorded from 10 of the 36 cameras for survey period one was expressed as 27.78 % (10/36) and 15 of the 36 cameras during survey period two was expressed as 41.67% (15/36). The mean and standard errors were derived from percentage activity values for the two survey periods. So using the above example, this involved summing 27.78% + 41.67% to derive a mean of 34.73% with a standard error of 6.94. The activity rate was calculated for all exotic predator species recorded so that additional affects could be considered. Where relevant, this data was pooled so as to explore the cumulative activity levels and provide an alternative comparison between the Year 1 and preconstruction baseline datasets.

2.3.2 Spotlight Surveys

The spotlight monitoring data is derived from a mean of the four spotlighting surveys and expressed as the number of Bettong recorded on a per hour of effort. For example, one Bettong observed during the first spotlight survey followed by no Bettong recorded on the remaining three surveys was expressed as 0.25 Bettong per hour of spotlight effort. Two

Bettong recorded on one survey and another one on another survey was expressed as 0.75 per hour of spotlighting effort.

2.3.3 Nocturnal Drive Transects

The nocturnal drive transects data is derived from a mean of the two 2-3 km transect surveys and expressed as the number of Bettong recorded per 2-3 km of effort.

2.3.4 Road Kill Surveys

The road kill monitoring data is derived from a tally of the total number of kilometers driven through areas of suitable Bettong habitat under construction and simply expressed as the number of individuals recorded. This was then compared with the baseline data using the number of Bettong recorded per 750 and 1500 km.

3.0 SURVEY RESULTS

3.1 Presence of Bettong at Monitoring Sites

Bettong were recorded at Site 1A (23125) but not at the adjacent control site 1B located 3 km to the east in Yuraygir State Conservation Area despite the area having historically produced Bettong during nocturnal drive transects over the years (Russell Jago pers. comm., May 2014). Bettong were recorded at both Site 2A (27420) and Site 2B which lies further to the north-west in Glenugie State Forest (Table 3-1; Figure 3-1; Plate 3-1).

Table 3-1. Summary of the paired treatment sites and Bettong tenure.

W2B Section	BACI Site Name	Mitigation Treatment	Bettong Recorded	BACI Site Name	Bettong Recorded
2	Impact 1 (23125)	dedicated culvert 2.4 x 3, 22m long	Yes	Control 1 (Yuraygir State Conservation Area)	No
2	Impact 2 (27420)	combined culvert 3.6 x 2.4, 104m long	Yes	Control 2 (Glenugie State Forest west)	Yes

3.2 Bettong Activity Levels

Bettong activity levels ranged from zero at Site 1A and 1B through to 9.69% at Site 2A and 27.78% at Site 2B (Table 3-2; Figure 3-2). At Site 1, the impact treatment (1A) recorded a decline, down from the 1.4% recorded in the baseline survey to 0% in Year 1. The paired control site (1B) continued to record 0% activity as it had done so in the baseline survey. At Site 2, both the impact (2A) and control (2B) treatments recorded increases in Bettong activity, with 2A increasing from 8.5% to 9.69% and 2B from 26.4% to 29.17%, an increase of 1.19% and 2.77% respectively in Year 1. These activity levels translate to approximately one in every 12 cameras being visited by Bettong at Site 2A and one in every 3-4 cameras being visited by Bettong at Site 2B. Both of the treatments recorded similar standard errors or variances between the winter and summer survey with 2A maintaining its high variability (se = 6.98) as it had done so previously for the baseline survey whilst 2B remained static (se = 1.39; Table 3-2).

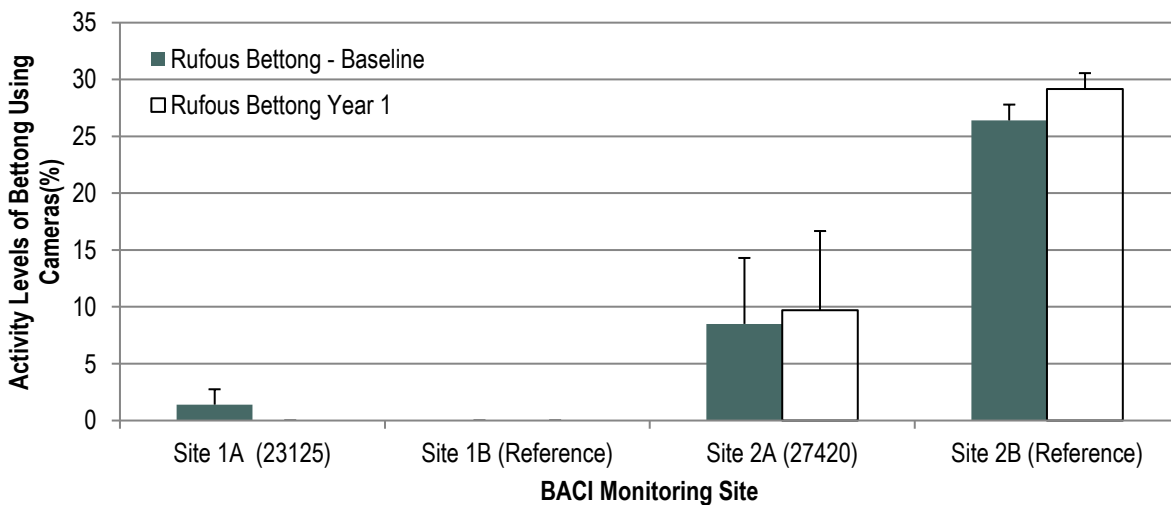


Figure 3-2. Activity levels (+s.e. bars) for Bettong between the preconstruction baseline survey (shaded) and Year 1 during construction survey (unshaded).

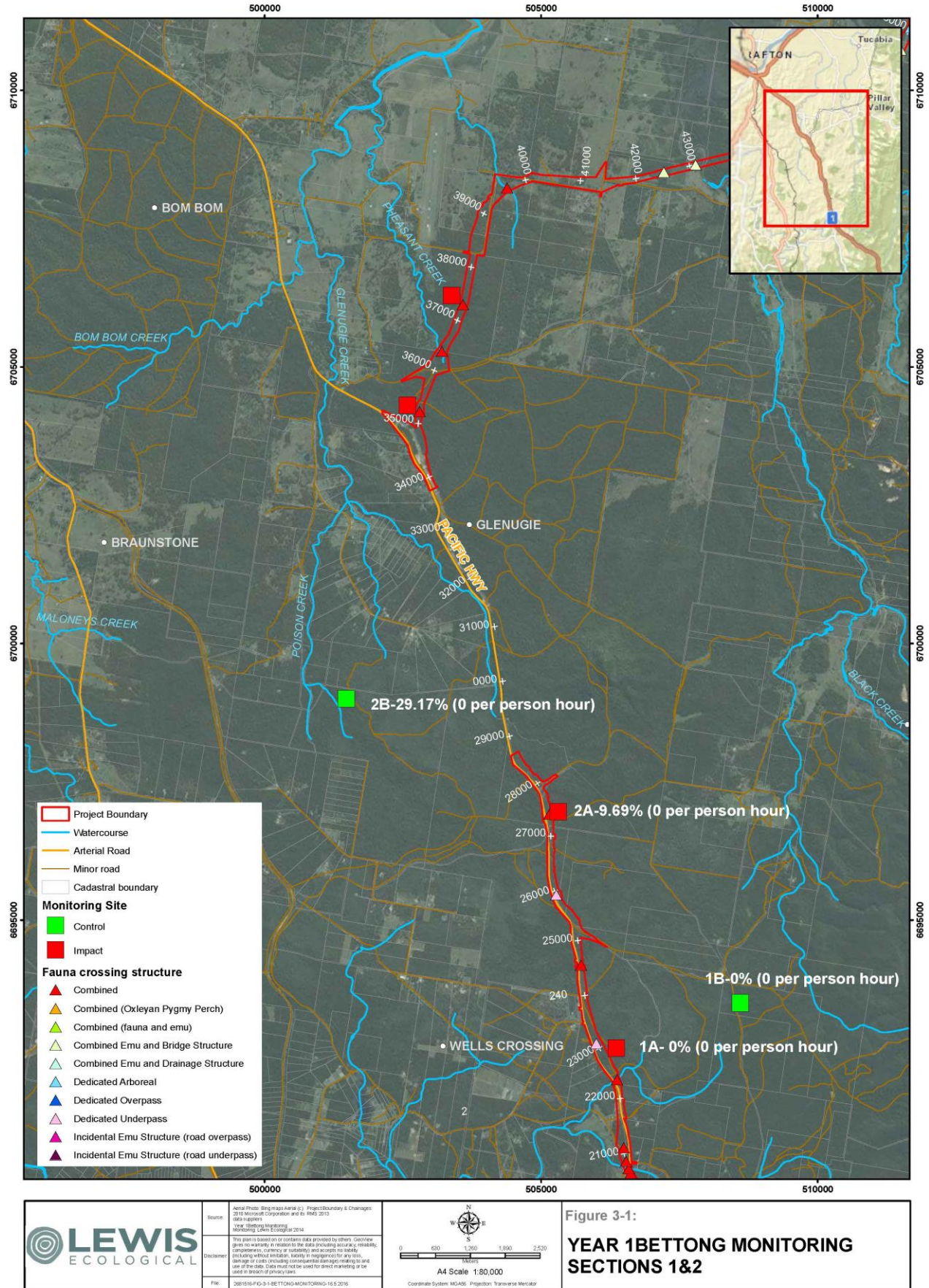


Figure 3-1. Year 1 mean activity levels and mean spotlight counts of Bettong at BACI Sites 1-2.



Plate 3-1. Example of a Rufous Bettong image recorded on the grid from Site 2B during summer sampling (Glenugie State Forest).

Table 3-2. Summary of the activity rates including mean values (\pm se) of Bettong.

Bettong Site Reference Name	Site 1A- Impact	Site 1B - Ref	Site 2A - Impact	Site 2B - Ref
Preconstruction Baseline Monitoring				
Bettong Survey 1	2.7	0.0	2.7	25
Bettong Survey 2	0.0	0.0	14.3	27.78
Preconstruction Baseline Mean	1.4	0.0	8.5	26.4
Preconstruction Baseline \pm se	\pm 1.4	\pm 0.0	\pm 5.8	\pm 1.4
During Construction Monitoring				
Winter 2015 (Year 1)	0	0	2.7	27.78
Summer 2016 (Year 1)	0	0	16.67	30.56
Year 1 Mean	0	0	9.69	29.17
Year 1 \pm se	0	0	6.98	1.39
Increase/Decrease Between Baseline and Year 1	Decrease	No Change	Increase	Increase

Shading denote the comparable means

3.3 Spotlight Surveys and Nocturnal Driving Transects for Bettong

Spotlight surveys recorded one possible Bettong at Site 2B during both the winter and summer surveys and another at Site 2A, however, these could not be confirmed as the individuals tend to move off into dense shrubs or tall stands of perennial grasses. Consequently, all four sites have a Year 1 detection rate of zero Bettong per hour of spotlight effort (Table 3-3; Figure 3-1). Similarly, nocturnal road transects recorded no Bettong from any of the four monitoring sites and consequently, the mean detection rate currently sits at zero Bettong per 2-3 km of driving transect.

Table 3-3. Results of the spotlight surveys and nocturnal drive transects for Bettong.

W2B Section	Site	Survey Technique	Winter Year 1		Summer Year 1		Baseline Mean No. Bettong/Phascogale Per Sampling Hour (Spotlighting) and per 2-3 km of nocturnal drive transect
			Spot. 1	Spot. 2	Spot. 3	Spot. 4	
2	Site 1a Impact	Spotlight	0	0	0	0	0
		Nocturnal Drive Transect	0	0	0	0	0
2	Site 1b Reference	Spotlight	0	0	0	0	0
		Nocturnal Drive Transect	0	0	0	0	0
2	Site 2a Impact	Spotlight	0 (pos 1)	0	0	0	0
		Nocturnal Drive Transect	0	0	0	0	0
2	Site 2b Reference	Spotlight	0	0 (pos 1)	0	0 (pos 1)	0
		Nocturnal Drive Transect	0	0	0	0	0

Pos. denotes a possible Bettong but could not be confirmed.

3.4 Road Kill Transects for Bettong and Phascogale

Road kill surveys performed over 25 days and 197 km of driving recorded the following:

- Winter sampling recorded one adult Bettong from Site 1A from 90 km of driving over 11 days (Table 3-4; Plate 3-2). The Bettong was an adult recorded from ch. 23600 (Pacific Highway near Parker Road) in mid July with a sign posted speed of 80 kmph. Recent clearing for site controls (i.e. access, basins) was noted.
- Summer sampling recorded one adult Bettong between Site 1A and Site 2A from 107 km of driving over 14 days (Table 3-4; Plate 3-2). The Bettong was an adult recorded from ch. 24600 (drainage line south of Bald Knob Tick Gate Road) on the 16th February with a sign posted speed of 80 kmph. Most of the clearing operations had been undertaken in this area at that time.

The two recorded Bettong equates to one Bettong per 98.5 km of road kill transect, markedly higher than one Bettong per 1500 km recorded in the baseline survey.



Plate 3-2. Road kill Bettong recorded during winter monitoring (July 2015) from ch. 23600 or adjacent Site 1A.

Table 3-4. Summary of road kill surveys performed during the preconstruction baseline survey.

Date	Road Kill Surveys - Distance Travelled (KM)	W2B Section	Outcome/Result
Winter Construction Survey-Year 1			
04.07.2015	7	Section 2	
08.07.2015	7	Section 2	
11.07.2015	7	Section 2	Adult Bettong edge of south bound lane. Clearing noted within 100 m to the east ch. 23600
24.07.2015	7	Section 2	
25.07.2015	7	Section 2	
18.08.2015	9	Section 2	
19.08.2015	9	Section 2	
20.08.2015	12	Section 2	
01.09.2015	10	Section 2	
02.09.2015	8	Section 2	
03.09.2015	7	Section 2	
Winter Total	90	Section 2	
Summer Construction Survey-Year 1			
12.01.2016	7	Section 2	
13.01.2016	7	Section 2	
02.02.2016	7	Section 2	
05.02.2016	7	Section 2	
11.02.2016	10	Section 2	
13.02.2016	7	Section 2	
16.02.2016	7	Section 2	Adult bettong struck on north bound fog line ch. 24600. Combined use culvert being installed along this drainage line.
20.02.2016	7	Section 2	
23.02.2016	7	Section 2	
25.02.2016	10	Section 2	
29.02.2016	10	Section 2	
01.03.2016	7	Section 2	
03.03.2016	7	Section 2	
07.03.2016	7	Section 2	
Summer Total	107	Section 2	

3.5 Exotic Predator Activity Levels

Using the cameras to calculate presence and activity levels for exotic predators, the following Year 1 activity levels were recorded at each site:

- Site 1A with:
 - 5.5% Wild Dog activity, **an increase from the baseline survey;**
 - 0% Red Fox activity and reflects no change from the baseline survey;
 - 0% Feral Cat activity and reflects no change from the baseline survey; and
 - 2.7% Feral Pig activity which **had not been previously recorded in the baseline survey** (Table 3-5).
- Site 1B with:
 - 4.15% Wild Dog activity, **an increase from the baseline survey;**
 - 0% Red Fox activity and reflects no change from the baseline survey;

- 2.3% Feral Cat activity, **an increase from the baseline survey**; and
- 2.7% Feral Pig activity which had only been detected via diggings in the baseline survey (Table 3-5).
- Site 2A with:
 - 13.9% Wild Dog activity, **a fivefold increase from the baseline survey** (Plate 3-3; Table 3-5);
 - 0% Red Fox activity, a decrease from the baseline survey;
 - 0% Feral Cat activity; no change from the baseline survey; and
 - 0% Feral Pig activity, no change from the baseline survey.
- Site 2B with:
 - 0% Wild Dog activity, no change from the baseline survey (Table 3-5);
 - 0% Red Fox activity, no change from the baseline survey;
 - 0% Feral Cat activity, a decline from the baseline survey; and
 - 0% Feral Pig activity, no change from the baseline survey.

Table 3-5. Exotic animal activity for each monitoring site.

W2B Section	Site	Fox	Winter Activity (%)	Summer Activity (%)	Year 1 Mean Activity (%)	Year 1 S.E	Pre-construction Baseline Mean (%)	Increase or Decrease in Activity between Baseline and Year 1 Survey
2	Site Impact 1a	Red Fox	0	0	0.00	0	0	No Change
		Wild Dog	2.7	8.3	5.5	2.8	4.2	Increase
		Feral Cat	0	0	0.00	0	0	No Change
		Feral Pig	0	2.7	1.35	1.35	0	Increase
2	Site Reference 1b	Red Fox	0	0	0.00	0	0	
		Wild Dog	0	8.3	4.15	4.15	2.8	Increase
		Feral Cat	5.6	0	2.30	2.8	1.4	Increase
		Feral Pig	2.7	5.6	4.15	1.45	0.0	Increase
2	Site Impact 2a	Red Fox	0	0	0.00	0	2.8	Decrease
		Wild Dog	16.7	11.1	13.90	2.8	2.8	Increase
		Feral Cat	0	0	0.00	0	0	No change
		Feral Pig	0	0	0.00	0	0	No Change
2	Site Reference 2b	Red Fox	0	0	0.00	0	0	No change
		Wild Dog	0	0	0.00	0	0	No change
		Feral Cat	0	0	0.00	0	2.8	Decrease
		Feral Pig	0	0	0.00	0	0	No Change

Red Fox was absent from Year 1 monitoring which represents a decrease from the baseline survey when it had been recorded at Site 2A. In contrast, Wild Dog activity levels have increased across all sites, particularly Site 2A where levels have risen from 2.8% during the baseline survey to 13.9% in Year 1, a fivefold increase. The paired Site 2B continues to show no sign of Wild Dog.

Feral Cat activity remains undetected at both the impact treatment sites whilst low activity levels continue to be recorded at both of the reference or control sites. Feral Pig was detected for the first time at Site 1A whilst activity levels have increased at the paired reference Site 1B. This species remains absent from Site 2A and 2B further to the north.



Plate 3-3. Image of Wild Dog recorded from Site 2A (ch. 27420).

4.0 DISCUSSION OF RESULTS

4.1 Bettong Activity

Year 1 sampling has confirmed the continued presence of Bettong from three of the four monitoring sites. The continued absence of Bettong from Site 1B suggests individuals may only periodically inhabit this area given they have been historically (circa 2010) observed adjacent to the grid (R. Jago pers. comm; May 2014). Since the completion of the preconstruction baseline surveys in 2014, a wildfire has burnt the trapping grid and surrounding lands, and in doing so it has removed parts of the mesic understorey and allowed fire tolerant grasses (i.e. Bladey Grass, *Imperta cylindrica*) and other ground covers to recolonise (Plate 4-1). The preconstruction surveys identified that fire was probably needed to improve overall habitat quality to Bettong, so future monitoring will prove useful to see if this in fact the case. Perhaps fortuitously, Site 1A was also burnt to the same extent and in doing so, the potential confounding factors of trying to compare a burnt and unburnt site have been avoided.



Plate 4-1. Site 1B illustrating the loss of regenerating shrub and understorey with recovering grasses and herb layer.

Bettong activity levels are in many ways similar to the preconstruction baseline sampling. At Site 1A, a road kill Bettong was recorded during the winter monitoring period whilst there has been no images of Bettong on the nearby camera trap grid. cursory surveys at other times between the winter and summer monitoring have yielded another Bettong from this location (i.e. 12th September 2015) indicating individuals frequent the road verge. With this in mind, it is becoming increasingly likely that Bettong are more prevalent on the western side of the existing carriageway and this will have implications in trying to determine the effectiveness of the dedicated underpass structure currently being installed at ch. 23125 (Wells Crossing).

Further north, both Site 2A and 2B recorded small incremental increases when compared to the preconstruction baseline data. The impact site (2A) does show the same increased variability between the two sampling events, however, this same pattern was recorded during the preconstruction baseline surveys and does not warrant concern at present.

4.2 Exotic Predatory Species

There has been some variability in the recorded levels of exotic predator activity. The most notable of these is the Wild Dog activity at Site 2A which has increased fivefold from 2.78% in the baseline survey to 13.9% along with photographic evidence of adult dogs and their pups. This increase in activity may partly explain the absence of Red Fox which generally avoids areas with high numbers of Wild Dogs (Saunders *et al.* 1995; Saunders and McLeod 2007; Mitchell and Balough 2007). The rate of increase should draw attention as to how exotic predators will influence the use of the 3.6 m x 2.4 m underpass culvert currently being installed to restore habitat connectivity at this location.

5.0 BASELINE AND YEAR 1 DATA, THRESHOLDS AND CORRECTIVE ACTIONS

The purpose of this section is to review the Year 1 population monitoring data by way of comparison with the baseline population monitoring data. Where differences occur, this has been measured against the acceptable thresholds formulated in the baseline survey (see Lewis 2015). When thresholds have been exceeded, a series of corrective actions identified in the baseline survey have been proposed. A summary of each measurable dataset is shown in Table 5-1 and discussed in each relevant section below.

5.1 Bettong Activity Levels

Bettong activity has declined at Site 1A, although the reported decline is within the acceptable <15% threshold outlined in the preconstruction baseline survey (Lewis 2015; Table 5-1). Further to the north at Site 2, both the impact and control site have had incremental increases. Consequently, the activity levels recorded are within the acceptable thresholds and no corrective actions are currently proposed.

5.2 Exotic Predator Activity Levels

There have been notable increases in exotic predator levels (Table 5-1). Both treatments at Site 1 recorded increases in Wild Dog activity levels of between 23.7% and 32.5% with the control site (1B) recording the greater increase. Feral Cat recorded a 39% increase, but only at the control treatment site (1B), whilst no change was recorded at the impact site. In either case, they do not exceed the 25% threshold at Site 1. Site 2 in contrast, has experienced a fivefold increase in Wild Dog activity at the impact treatment (2A) with 2.8% in the baseline survey increasing to 13.9% in Year 1. When the exotic predator data are pooled, there was still a recorded twofold increase (5.6% in baseline versus a 13.9% in Year 1). As the control treatment remained static during the same period, the threshold has been exceeded, indicating the corrective action "*Review and consider current exotic predator control program*" are warranted.

5.3 Spotlighting and Nocturnal Drive Transects for Bettong

Both spotlighting and nocturnal drive transects recorded lower numbers of Bettong than the baseline survey (Table 5-1). This was attributed to no Bettong being spotlighted or recorded during drive transects of Site 2 whilst there was no change at Site 1 where Bettong have not been recorded during either survey period. One of the main difficulties associated with spotlighting these monitoring sites is the dense pockets of shrubs and tall grass which enable Bettong to seek shelter and thus avoid detection, or more often the case, heard as they move away from the surveyor and avoid confirmation (Plate 5-1).

Given the camera monitoring at Site 2 actually recorded an increase in Bettong activity, the decline recorded in the spotlighting and nocturnal drive transect data should be ignored. This is due to the fact that spotlighting and nocturnal drive transects were considered an unreliable technique in the baseline survey (see Lewis 2015 and recommendations there in) for monitoring Bettong and only provide complementary data such as determining presence or behavioural observations of animals attempting to cross roads. Their use during Year 1 supports the earlier recommendation and

consequently it should now be removed from the sampling regime and the Threatened Mammal Management Plan updated to reflect this, not as it currently reads where it may or may not be undertaken.



Plate 5-1. Site 2A illustrating the extent of tall grass and the challenges of spotlighting a Bettong.

5.4 Road Kill Monitoring

Year 1 monitoring was undertaken during the initial stages of clearing and grubbing and the commencement of bulk earthworks. Consequently, none of the connectivity structures (i.e. underpasses) and associated permanent exclusion fencing had been installed.

With the above in mind, more Bettong were recorded during the Year 1 road kill surveys than had been recorded during the baseline survey with two individuals from 197 km of driving compared to just one individual from 1500 km driving in the baseline survey (Table 5-1). This represents a fifteen fold increase or one Bettong per 98.5 km of driving. It does not take into account a third individual which had been struck on the 12th September 2015 adjacent to Site 1A but serves to highlight Bettong utilise the road corridor between ch. 23000-24000 (Wells Crossing) then perhaps the area further to the east where the camera trapping grid is located.

No specific threshold or tolerance level is provided in the Threatened Mammal Management Plan for monitoring during the construction period. Earlier versions of the Threatened Mammal Management Plan (2.1, April 2015) make a specific provision for the pre-clearing ecologist survey to advise if temporary exclusion fencing is required where threatened mammals occur so as to direct them away from threats such as the active construction area or existing highway (Section 6.3.4). No Bettong were recorded during the pre-clearing surveys, and consequently, no temporary fauna fencing was recommended (EcoSure 2017). Road kill monitoring performed as part of Year 1 surveys identified three road kill Bettong adjacent to or shortly after the clearing operations.

Table 5-1. Summary of survey techniques, baseline data and Year 1 winter survey results in relation to acceptable tolerance levels for Bettong.

Technique	Description	Priority for Inclusion into The Post Construction Monitoring Program	Acceptable Tolerance Level From the Control Site	Bettong Site Reference Name	Site 1A - Impact	Site 1B - Control	Site 2A - Impact	Site 2B - control
Camera Traps	36 cameras installed on a 600 x 600 m grid	High	15% decline of Bettong and	Baseline - Bettong Mean	1.4	0.0	8.5	26.4
				Bettong Year 1	0	0	9.7	29.17
				Comment	Recorded decline however result comparable to baseline	No change	A 12% increase from the baseline survey	A 9.5% increase from the baseline survey
			25% increase in exotic predators	Baseline - Red Fox	0	0	2.8	0
				Year 1 – Red Fox	0	0	0	0
				Baseline - Wild Dog	4.2	2.8	2.8	0
				Year 1 – Wild Dog	5.5	4.15	13.9	0
				Baseline – Feral Cat	0	1.4	0	2.8
				Year 1 – Feral Cat	0	2.3	0	0
				Comment	Increase activity of Wild Dog is comparable to Site 1B	Increase activity of Wild Dog is comparable to Site 1B. Increase activity of Feral Cat is isolated to control treatment only.	Fivefold increase in Wild Dog activity not supported by increases in neighbouring control Site 2B. Threshold exceeded and corrective action required.	Low exotic predator activity
Spotlight Surveys	4 units x 1 person hour (30 min per person) non-consecutive nights	Low	50% decline	Baseline Mean	0	0	1	0.5
				Year 1	0	0	0	0
				Comment	No change	No change	Data shows decline at present. Survey technique not reliable.	Data shows decline at present. Survey technique not reliable.
Nocturnal Drive Transect	4 units of 2-3 km transect employed on	Low	Absence after 2 years of monitoring	Baseline Mean	0	0	0.25	0

Technique	Description	Priority for Inclusion into The Post Construction Monitoring Program	Acceptable Tolerance Level From the Control Site	Bettong Site Reference Name	Site 1A - Impact	Site 1B - Control	Site 2A - Impact	Site 2B - control
	nights of spotlight surveys							
				Year 1 Winter	0	0	0	0
				Comment	No change	No change	Data shows decline at present. Survey technique not reliable.	No change
Road Kill Surveys	surveys on multiple days and season in areas of suitable habitat and distance recorded	Moderate	>200% increase	Preconstruction Base	1 Bettong per 1500 km of road transect			
				Year 1	2 Bettong from 197 km road transect			
				Comment	No road kill Bettong from Site 1A during baseline period although previous observations in this area. Another Bettong recorded 300 m from previous location on 12 th September. Corrective actions required.			

6.0 CONCLUSION & RECOMMENDATIONS

Year 1 sampling has confirmed the continued presence of Bettong at three of the four monitoring sites and in many ways this is representative of the baseline surveys performed in 2014 (Lewis 2015). There is however, a reliance on the road kill data to confirm the continued presence of Bettong from Site 1A where Bettong were recorded in July and September 2015 as road killed individuals around the time of clearing operations. Further north at Site 2, both treatments recorded increases in Bettong activity and interestingly, the impact treatment (Site 2A) recorded the same high variability between the first and second sampling periods and mirrors that of the baseline survey. Consequently, this variability cannot be attributed to a behavioural response to the clearing operations which occurred just 4 weeks prior to winter sampling.

Exotic predator levels have increased across most of the monitoring sites. At Site 1, both treatments recorded increases in Wild Dog activity levels, however, these are within the acceptable thresholds even when all exotic species data is pooled. In contrast, Site 2 recorded a fivefold increase in Wild Dog activity levels at Site 2A whilst no change was recorded at Site 2B. Consequently, the 25% increase threshold has been exceeded and remains so when all of the exotic predator data is pooled. Consequently, some corrective actions are required in relation to Site 2A (ch.27420), namely engage with the Northern Rivers Catchment Management Authority, EPA (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk.

The road kill monitoring has confirmed an increase in the number of Bettong being struck between the baseline survey and Year 1. Whilst relatively small numbers are reported here, the reoccurring rate is likely to influence the population dynamics at a localised scale, particularly Site 1A (ch. 23125) where individuals appear to frequent the existing road corridor. As the data recorded in Year 1 exceeds the acceptable threshold, some corrective action is applicable and includes the installation of permanent fauna exclusion fencing as per the Fauna Connectivity Strategy and ensure its completion before opening to traffic.

In light of the findings, some recommendations have been proposed to assist the monitoring program for Year 2 including:

- 1) Bring forward the permanent fauna exclusion fencing program for areas between ch. 22000-28000 (i.e. Wells Crossing to Glenugie);
- 2) Investigate the feasibility of installing a second camera trapping grid to the west of ch. 23125 as this information would inform the likely effectiveness of the dedicated underpass structure currently being installed at ch. 23125. Put simply, the author predicts Bettong occur almost exclusively on the western side of the newly constructed carriageway and this distribution will ultimately impact on the way Bettong use the dedicated underpass at ch. 23125; and

- 3) RMS and PacificComplete review and consider their current approach to managing predators around fauna connectivity structures due to become operational in the next 12 months. This should include implementing a pest control program at culvert 27420.

7.0 REFERENCES

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8.0 APPENDIX 1 – RAW FIELD DATA

Table A1. Location of the Bettong Monitoring Grids with individual camera locations

Site Name	Site	Camera No	Survey	GPS Waypoint name	Latitude	Longitude
Bettong Site 1 Impact	1a	1	1	B site 1-1	-29.899194	153.064427
Bettong Site 1 Impact	1a	2	1	B site 1-2	-29.89894	153.065402
Bettong Site 1 Impact	1a	3	1	B site 1-3	-29.898715	153.066402
Bettong Site 1 Impact	1a	4	1	B site 1-4	-29.898465	153.06748
Bettong Site 1 Impact	1a	5	1	B site 1-5	-29.898183	153.068445
Bettong Site 1 Impact	1a	6	1	B site 1-6	-29.89798	153.069479
Bettong Site 1 Impact	1a	7	1	B site 1-7	-29.89711	153.06922
Bettong Site 1 Impact	1a	8	1	B site 1-8	-29.897317	153.068186
Bettong Site 1 Impact	1a	9	1	B site 1-9	-29.897667	153.067206
Bettong Site 1 Impact	1a	10	1	B site 1-10	-29.897721	153.066293
Bettong Site 1 Impact	1a	11	1	B site 1-11	-29.898011	153.065299
Bettong Site 1 Impact	1a	12	1	B site 1-12	-29.898282	153.064265
Bettong Site 1 Impact	1a	13	1	B site 1-13	-29.897369	153.063951
Bettong Site 1 Impact	1a	14	1	B site 1-14	-29.897217	153.064983
Bettong Site 1 Impact	1a	15	1	B site 1-15	-29.89683	153.065937
Bettong Site 1 Impact	1a	16	1	B site 1-16	-29.896682	153.066947
Bettong Site 1 Impact	1a	17	1	B site 1-17	-29.896423	153.067859
Bettong Site 1 Impact	1a	18	1	B site 1-18	-29.896231	153.068901
Bettong Site 1 Impact	1a	19	1	B site 1-19	-29.895371	153.068559
Bettong Site 1 Impact	1a	20	1	B site 1-20	-29.895695	153.067519
Bettong Site 1 Impact	1a	21	1	B site 1-21	-29.895891	153.066424
Bettong Site 1 Impact	1a	22	1	B site 1-22	-29.896132	153.065341
Bettong Site 1 Impact	1a	23	1	B site 1-23	-29.896529	153.064442
Bettong Site 1 Impact	1a	24	1	B site 1-24	-29.896526	153.063442
Bettong Site 1 Impact	1a	25	1	B site 1-25	-29.895703	153.063161
Bettong Site 1 Impact	1a	26	1	B site 1-26	-29.895664	153.064244
Bettong Site 1 Impact	1a	27	1	B site 1-27	-29.8952	153.065055
Bettong Site 1 Impact	1a	28	1	B site 1-28	-29.895034	153.066036
Bettong Site 1 Impact	1a	29	1	B site 1-29	-29.89483	153.067128
Bettong Site 1 Impact	1a	30	1	B site 1-30	-29.894572	153.068124
Bettong Site 1 Impact	1a	31	1	B site 1-31	-29.893764	153.067802
Bettong Site 1 Impact	1a	32	1	B site 1-32	-29.893951	153.066767
Bettong Site 1 Impact	1a	33	1	B site 1-33	-29.894206	153.065722
Bettong Site 1 Impact	1a	34	1	B site 1-34	-29.894408	153.064701
Bettong Site 1 Impact	1a	35	1	B site 1-35	-29.894715	153.063692
Bettong Site 1 Impact	1a	36	1	B site 1-36	-29.894918	153.062651
Bettong Site 1 Reference	1b	1	1	B site 1ref-1	-29.887968	153.090371
Bettong Site 1 Reference	1b	2	1	B site 1ref-2	-29.887856	153.089425
Bettong Site 1 Reference	1b	3	1	B site 1ref-3	-29.887534	153.088455
Bettong Site 1 Reference	1b	4	1	B site 1ref-4	-29.887318	153.087473

Site Name	Site	Camera No	Survey	GPS Waypoint name	Latitude	Longitude
Bettong Site 1 Reference	1b	5	1	B site 1ref-5	-29.887156	153.08653
Bettong Site 1 Reference	1b	6	1	B site 1ref-6	-29.887025	153.085476
Bettong Site 1 Reference	1b	7	1	B site 1ref-7	-29.887974	153.085323
Bettong Site 1 Reference	1b	8	1	B site 1ref-8	-29.888038	153.08633
Bettong Site 1 Reference	1b	9	1	B site 1ref-9	-29.888234	153.087326
Bettong Site 1 Reference	1b	10	1	B site 1ref-10	-29.888479	153.088379
Bettong Site 1 Reference	1b	11	1	B site 1ref-11	-29.888804	153.089373
Bettong Site 1 Reference	1b	12	1	B site 1ref-12	-29.888884	153.090415
Bettong Site 1 Reference	1b	13	1	B site 1ref-13	-29.889751	153.09027
Bettong Site 1 Reference	1b	14	1	B site 1ref-14	-29.889593	153.089264
Bettong Site 1 Reference	1b	15	1	B site 1ref-15	-29.889336	153.088222
Bettong Site 1 Reference	1b	16	1	B site 1ref-16	-29.8892	153.087182
Bettong Site 1 Reference	1b	17	1	B site 1ref-17	-29.888908	153.086242
Bettong Site 1 Reference	1b	18	1	B site 1ref-18	-29.888857	153.08524
Bettong Site 1 Reference	1b	19	1	B site 1ref-19	-29.890642	153.090377
Bettong Site 1 Reference	1b	20	1	B site 1ref-20	-29.890512	153.08935
Bettong Site 1 Reference	1b	21	1	B site 1ref-21	-29.890256	153.088407
Bettong Site 1 Reference	1b	22	1	B site 1ref-22	-29.890087	153.087444
Bettong Site 1 Reference	1b	23	1	B site 1ref-23	-29.889788	153.086427
Bettong Site 1 Reference	1b	24	1	B site 1ref-24	-29.889773	153.08525
Bettong Site 1 Reference	1b	25	1	B site 1ref-25	-29.890644	153.085521
Bettong Site 1 Reference	1b	26	1	B site 1ref-26	-29.890639	153.086617
Bettong Site 1 Reference	1b	27	1	B site 1ref-27	-29.89096	153.087578
Bettong Site 1 Reference	1b	28	1	B site 1ref-28	-29.891075	153.088798
Bettong Site 1 Reference	1b	29	1	B site 1ref-29	-29.89126	153.089635
Bettong Site 1 Reference	1b	30	1	B site 1ref-30	-29.891546	153.090544
Bettong Site 1 Reference	1b	31	1	B site 1ref-31	-29.892468	153.090396
Bettong Site 1 Reference	1b	32	1	B site 1ref-32	-29.892149	153.089355
Bettong Site 1 Reference	1b	33	1	B site 1ref-33	-29.8919	153.088427
Bettong Site 1 Reference	1b	34	1	B site 1ref-34	-29.891836	153.087353
Bettong Site 1 Reference	1b	35	1	B site 1ref-35	-29.89154	153.086397
Bettong Site 1 Reference	1b	36	1	B site 1ref-36	-29.891415	153.085357
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	1	2	Site 6-1	-29.856923	153.052939
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	2	2	Site 6-2	-29.856714	153.053956
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	3	2	Site 6-3	-29.856406	153.05495
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	4	2	Site 6-4	-29.856355	153.055983
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	5	2	Site 6-5	-29.856139	153.056984
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	6	2	Site 6-6	-29.856021	153.05797
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	7	2	Site 6-7	-29.856883	153.058305
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	8	2	Site 6-8	-29.856968	153.057295

Site Name	Site	Camera No	Survey	GPS Waypoint name	Latitude	Longitude
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	9	2	Site 6-9	-29.85723	153.056291
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	10	2	Site 6-10	-29.857343	153.055248
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	11	2	Site 6-11	-29.857614	153.05422
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	12	2	Site 6-12	-29.857851	153.053214
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	13	2	Site 6-13	-29.858754	153.053408
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	14	2	Site 6-14	-29.858473	153.054397
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	15	2	Site 6-15	-29.858265	153.0554
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	16	2	Site 6-16	-29.858132	153.056437
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	17	2	Site 6-17	-29.857797	153.057417
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	18	2	Site 6-18	-29.857829	153.058414
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	19	2	Site 6-19	-29.858756	153.058562
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	20	2	Site 6-20	-29.858752	153.057451
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	21	2	Site 6-21	-29.859097	153.05645
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	22	2	Site 6-22	-29.85916	153.055324
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	23	2	Site 6-23	-29.859361	153.054382
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	24	2	Site 6-24	-29.859677	153.053469
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	25	2	Site 6-25	-29.860526	153.053593
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	26	2	Site 6-26	-29.860278	153.054575
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	27	2	Site6-27	-29.860047	153.055555
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	28	2	Site 6-28	-29.86	153.056585
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	29	2	Site 6-29	-29.859683	153.057546
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	30	2	Site 6-30	-29.859625	153.058641
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	31	2	Site 6-31	-29.860553	153.058845
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	32	2	Site 6-32	-29.860565	153.057825
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	33	2	Site 6-33	-29.860777	153.056866
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	34	2	Site 6-34	-29.860891	153.055737
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	35	2	Site 6-35	-29.861172	153.054778
Bettong Site 2 Impact 2nd survey grid on eastern side	2a	36	2	Site 6-36	-29.861525	153.053697
Bettong Site 2 reference	2b	1	1	B site 2ref-1	-29.839419	153.013419
Bettong Site 2 reference	2b	2	1	B site 2ref-2	-29.839084	153.014383
Bettong Site 2 reference	2b	3	1	B site 2ref-3	-29.83887	153.015374
Bettong Site 2 reference	2b	4	1	B site 2ref-4	-29.838659	153.016351
Bettong Site 2 reference	2b	5	1	B site 2ref-5	-29.838471	153.017417

Site Name	Site	Camera No	Survey	GPS Waypoint name	Latitude	Longitude
Bettong Site 2 reference	2b	6	1	B site 2ref-6	-29.838226	153.018385
Bettong Site 2 reference	2b	7	1	B site 2ref-7	-29.840228	153.013995
Bettong Site 2 reference	2b	8	1	B site 2ref-8	-29.839886	153.014834
Bettong Site 2 reference	2b	9	1	B site 2ref-9	-29.839662	153.015814
Bettong Site 2 reference	2b	10	1	B site 2ref-10	-29.83953	153.01684
Bettong Site 2 reference	2b	11	1	B site 2ref-11	-29.839321	153.017834
Bettong Site 2 reference	2b	12	1	B site 2ref-12	-29.838997	153.018878
Bettong Site 2 reference	2b	13	1	B site 2ref-13	-29.839817	153.019307
Bettong Site 2 reference	2b	14	1	B site 2ref-14	-29.840126	153.018271
Bettong Site 2 reference	2b	15	1	B site 2ref-15	-29.840324	153.017256
Bettong Site 2 reference	2b	16	1	B site 2ref-16	-29.840457	153.016196
Bettong Site 2 reference	2b	17	1	B site 2ref-17	-29.840659	153.015209
Bettong Site 2 reference	2b	18	1	B site 2ref-18	-29.841145	153.014214
Bettong Site 2 reference	2b	19	1	B site 2ref-19	-29.838519	153.013074
Bettong Site 2 reference	2b	20	1	B site 2ref-20	-29.838278	153.014089
Bettong Site 2 reference	2b	21	1	B site 2ref-21	-29.837982	153.015111
Bettong Site 2 reference	2b	22	1	B site 2ref-22	-29.837744	153.016291
Bettong Site 2 reference	2b	23	1	B site 2ref-23	-29.837525	153.017308
Bettong Site 2 reference	2b	24	1	B site 2ref-24	-29.8373	153.018342
Bettong Site 2 reference	2b	25	1	B site 2ref-25	-29.836416	153.018465
Bettong Site 2 reference	2b	26	1	B site 2ref-26	-29.836673	153.01749
Bettong Site 2 reference	2b	27	1	B site 2ref-27	-29.836868	153.016487
Bettong Site 2 reference	2b	28	1	B site 2ref-28	-29.836984	153.014868
Bettong Site 2 reference	2b	29	1	B site 2ref-29	-29.837527	153.013971
Bettong Site 2 reference	2b	30	1	B site 2ref-30	-29.837679	153.01293
Bettong Site 2 reference	2b	31	1	B site 2ref-31	-29.841988	153.014289
Bettong Site 2 reference	2b	32	1	B site 2ref-32	-29.841604	153.015374
Bettong Site 2 reference	2b	33	1	B site 2ref-33	-29.841346	153.016314
Bettong Site 2 reference	2b	34	1	B site 2ref-34	-29.841341	153.017428
Bettong Site 2 reference	2b	35	1	B site 2ref-35	-29.841011	153.018425
Bettong Site 2 reference	2b	36	1	B site 2ref-36	-29.84071	153.019365