Melbourne Water Corporation

Sugarloaf Pipeline Project Toolangi Habitat Linkages Monitoring

Effectiveness of Coarse Woody Debris Linkages

May 2017

Acknowledgements

The following individuals or groups have assisted in the preparation of this report. However, it is acknowledged that the contents and views expressed within this report are those of GHD Pty Ltd and do not necessarily reflect the views of the parties acknowledged below:

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- Melbourne Water Corporation staff including Andrea Burns, Paul Evans, Alex Sneskov, Anna Zsoldos, Mark Scida, Warren Tomlinson and Steve McGill for providing assistance, support throughout the project

Abbreviations

ADJ	Undisturbed forest area, adjacent to the ROW
CWD	Coarse Woody Debris
DELWP	Victorian Department of Environment, Land, Water and Planning (formerly DEPI)
DEPI	Victorian Department of Environment and Primary Industries (now DELWP)
DSE	Department of Sustainability and Environment (now DELWP)
EPBC	Environment Protection and Biodiversity Conservation Act 1999
EVC	Ecological Vegetation Class
FFG	Flora and Fauna Guarantee Act 1988
GHD	GHD Pty Ltd
HNF	Highlands – Northern Fall Bioregion
HSF	Highlands – Southern Fall Bioregion
ROW	Right of Way (cleared area for construction of the Sugarloaf Pipeline)
MW	Melbourne Water Corporation
Spp.	More than one species
TSF	Toolangi State Forest

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1. Introduction

1.1 Background

The Sugarloaf Pipeline Project (the Pipeline) was completed in February 2010 and was constructed to enable the transfer of water from the Goulburn River in Yea to the Sugarloaf Reservoir, Christmas Hills. The Pipeline was initially managed and constructed by the Sugarloaf Pipeline Alliance (the Alliance), which included Melbourne Water Corporation (MW) and GHD Pty Ltd (GHD). Since completion of construction, the Pipeline has been managed solely by MW.

The Pipeline received State Government approval and Federal approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2008. Government approval was subject to conditions, which included the commitment to undertake works in accordance with requirements stated in an Environmental Management Strategy (EMS), which was prepared by the Alliance prior to construction. The requirement that forms the basis of this report is included in Attachment 7 of the EMS (Mitigation Plan for EPBC Act and FFG Act Listed Fauna Species). It states:

"*For a period of at least two years, the use of the habitat linkage crossings that have been installed within the Toolangi State Forest will be monitored for their effectiveness and usage by native fauna".*

The habitat linkages are habitat reinstatement measures implemented post-construction within the area cleared of forest for pipeline construction through Toolangi State Forest (TSF), with the aim of restoring connectivity across the disturbed area for fauna. Three types of habitat linkages were established for the project:

- Coarse woody debris (CWD), for ground-dwelling fauna
- Glider Poles, for arboreal and volant mammals
- Culverts, for bandicoots

This report covers the monitoring of the CWD habitat linkages only. The monitoring of glider poles was also completed by GHD, and is reported separately (in prep). The monitoring and reporting for culverts was completed by staff from the Arthur Rylah Institute (ARI), and is reported separately.

The habitat linkages monitoring program (the Project) was established in February 2013.

1.2 Study site

The study site (Figure 1) occurs within the Toolangi State Forest, Victoria, approximately 80 km to the northeast of Melbourne. The study site is located across the Highlands-Northern Fall (HNF) and Highlands-Southern Fall (HSF) Bioregions and comprises a mixture of Heathy Dry Forest, Damp Forest, Lowland Forest and Shrubby Foothill Forest Ecological Vegetation Classes (EVCs).

The Right of Way (ROW) (i.e. the easement within which the pipeline is constructed and from which forest was cleared) traverses north-south through Toolangi State Forest on the eastern side of the Melba Highway. The ROW ranges from 30 – 60 m wide. Because of the pipeline and the potential for future damage by roots, trees will not be permitted to re-grow within the ROW, but growth of shrubs and understorey vegetation will be permitted. Therefore, the ROW has the potential to create a long-term, forest-free barrier to forest fauna.

1.3 Creating a CWD habitat linkage

Coarse Woody Debris habitat linkages are areas where MW installed logs from trees that were cleared from the forest for pipeline construction within the ROW. CWD habitat linkages within the southern sections of the Toolangi State Forest cover much of the exposed ROW (i.e. there are few areas without CWD), whereas in the northern and central parts there are discrete habitat linkages, with areas between them that did not have CWD allocated. Consequently, monitoring was limited to the central and northern parts of the Toolangi State Forest to allow direct comparison with areas that do not include CWD habitat linkages (Figure 1).

1.4 Objective

The objective of this project was to monitor the effectiveness of the CWD habitat linkages to meet the requirements of the EMS. The program was based on the requirements set out in the EMS and as determined and agreed in 2013 in consultation with the Department of Environment, Land, Water and Planning (DELWP) (then DSE).

1.5 Limitations

This report has been prepared by GHD for Melbourne Water Corporation and may only be used and relied on by Melbourne Water Corporation for the purpose agreed between GHD and the Melbourne Water Corporation as set out in section 1 of this report.

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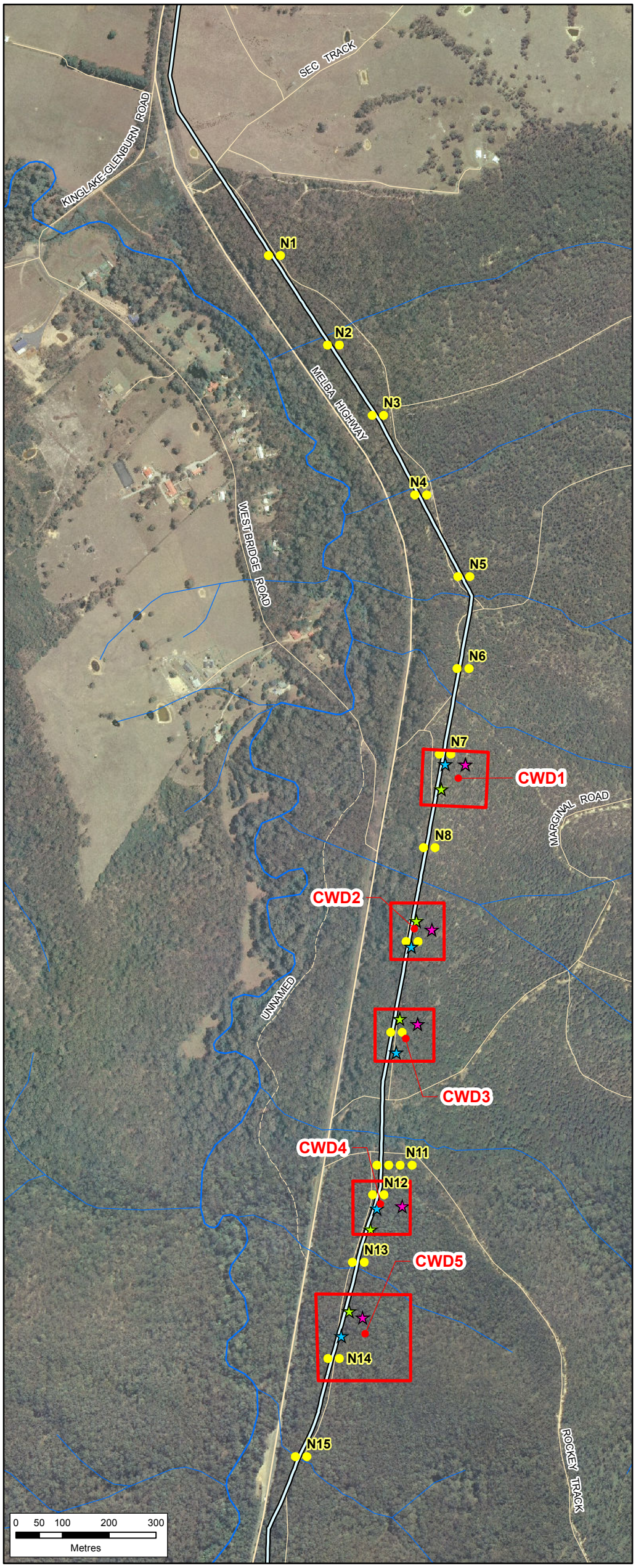
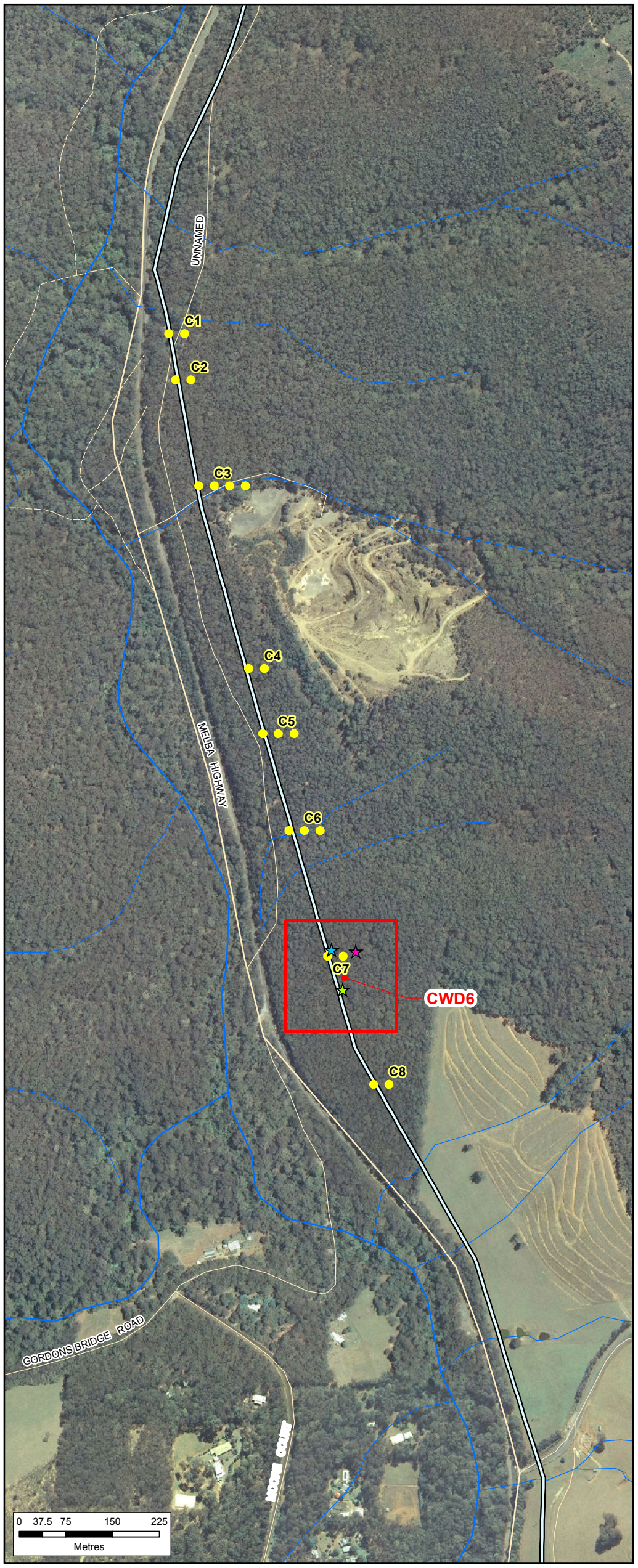
The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.





LEGEND

- CWD Treatment Area
- Glider Pole Locations
- Pipeline

Treatment Locations

- ADJ
- CWD
- ROW

Paper Size A3

As Shown

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Melbourne Water Corporation
Toolangi Habitat Linkages Monitoring

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Coarse Woody Debris Habitat Linkage Location

Figure 1

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Data source: MWC Imagery (2007) and VicMap (2007). Created by:lrsmith

2. Methods

2.1 Set up

Due to the considerable resources that would be required to effectively monitor all habitat linkages throughout Toolangi State Forest (TSF), a sub-sample of CWD habitat linkages was monitored in a way that aimed to detect representative patterns and processes of fauna movement across and around the ROW.

Linkages were selected for sampling based on maximizing information obtained by the monitoring. Only CWD habitat linkages in the northern and central sections of TSF were used as these were established originally during the pipeline's post-construction phase as discrete and clearly defined areas of CWD (Plate 1). This allowed direct comparison with neighboring areas of ROW that do not contain CWD (herein called ROW, Plate 2) and undisturbed forest areas adjacent to the ROW (herein called ADJ; Plate 3), which were included in an effort to measure fauna diversity and abundance in the forest (i.e., the suite of fauna that had the potential to use the linkages).

Plate 1 CWD camera set up

Plate 2 ROW camera set up

Plate 3 ADJ camera set up

2.1.1 Ground-based camera surveys

Ground-based surveillance cameras and incidental observations were used to monitor the use and effectiveness of CWD habitat linkages.

Surveillance camera surveys involve the use of un-manned motion-sensing cameras that are set up and left *in situ* to detect fauna over an extended period.

Four rounds of sampling were undertaken over a two-year period. For each round, 18 ground-based cameras were deployed, including six cameras within the ROW with CWD (CWD treatment), six cameras within the ROW without CWD (ROW treatment), and six cameras in the forest adjacent to and east of the ROW (ADJ treatment) (Figure 2). The 18 cameras were divided into six replicated sets, each with a ROW, CWD and ADJ camera.

Within each replicate set, CWD and ROW cameras were set up approximately 50 m from each other, and the ADJ camera was set up approximately 50 m from CWD and ROW cameras.

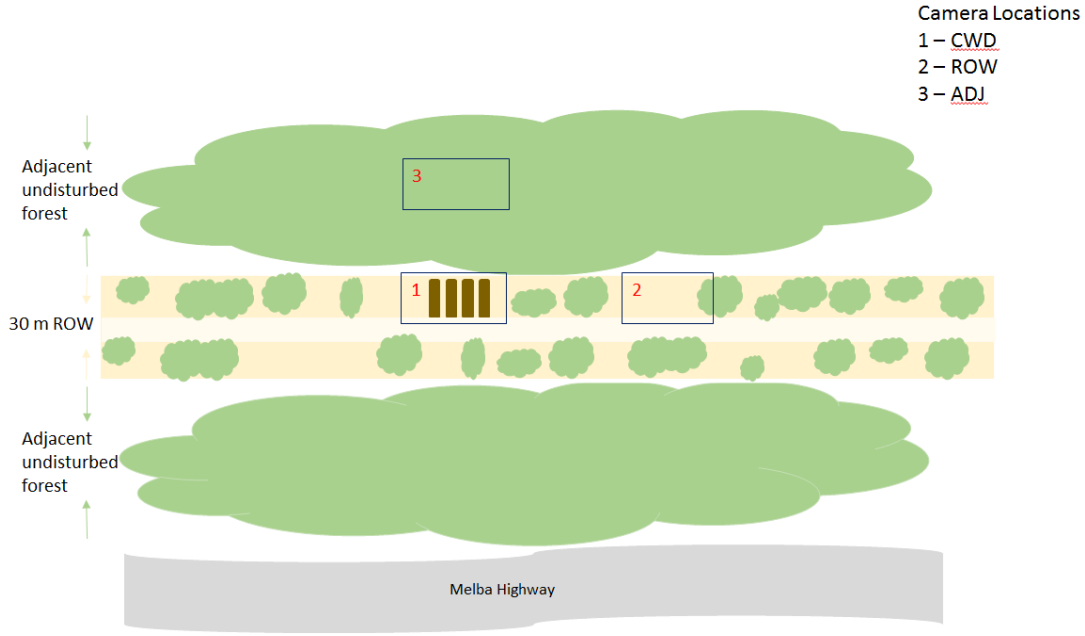

Figure 2 Habitat linkage camera set up (one set)

Not drawn to scale

Four types of cameras were used over the course of the monitoring period:

- UoVision UV535 Black OPS 5-6MP Trail Camera (Panda)
- Scout Guard DTC-530V Trail Camera (Scout Guard)
- Moultrie Gamespy i60 Trail Camera (Moultrie)
- Keep Guard KG 680 Trail Camera (Keep Guard)

Camera models were deployed haphazardly among sets and treatments to avoid bias.

Motion-sensing cameras are triggered by movement and were typically set to take a burst of three images[1] per trigger with the intent that each animal could be photographed in different positions to help with identification, if necessary (see section 2.3.1 for more information on triggers).

[1] That is, cameras take up to three shots when triggered three times but won't take more than three shots within one minute.

Within each treatment (i.e., CWD, ROW or ADJ), cameras were positioned and directed to maximise the chance of capturing images of fauna (i.e., making use of natural bottlenecks, such as between logs). Vegetation in front of the camera lens was trimmed or tied back to reduce the incidence of cameras being triggered by vegetation moving in the wind. The location of camera deployment was the same for each of the four rounds.

The following parameters were recorded for each camera deployed:

- Camera identification number
- Accurate location (GPS)
- Camera treatment type i.e. CWD/ROW/ADJ

2.1.2 Baiting

Generally, baits are used to attract fauna to unmanned cameras, as this greatly improves the likelihood of detecting animals. Without the use of baits, there is a very real chance that no/few animals will be detected at all during the two-year monitoring period, even though animals occur in the area and probably within the linkages.

For this project, efforts to *attract* fauna into the linkages had the potential to bias the results (i.e., fauna may have entered the linkage only because of the presence of the bait). Consequently, we did not bait cameras for this project.

2.2 Timing

Cameras were deployed for four sampling rounds, each lasting a minimum of four weeks (Table 1).

Table 1 Duration of the four sampling rounds

Sampling Round	Start Date	End Date	Season	No. of days cameras deployed	Average[2] no. of days cameras captured images
1	19 February 2013	3 April 2013	Summer/ Autumn	44	30
2	15 November 2013	16 December 2013	Summer	32	22
3	22 January 2015	2 March 2015	Summer/ Autumn	40	27
4	16 April 2015	14 May 2015	Autumn	29	21

Not all cameras remained operational during the deployment period due to technical issues (faulty SD cards, full SD cards, battery failure) however, this is largely mitigated by the replication of sets and rounds. Additionally faults were spread among the treatments and sets rather than skewed towards a particular treatment. Therefore the cleared treatment types had a similar average number of days that cameras were capturing images (CWD – average 24 days, ROW – average 27 days) with the ADJ treatment capturing images on average over more days per camera (average 37 days).

[2] The average number of days that cameras were operational in the field. I.e. if SD cards filled or there was a fault, cameras were no longer operational. Days where cameras were operational but no fauna were detected were still included.

2.3 Data analysis

2.3.1 Downloading and management of data

After each deployment period (sampling round), all cameras were collected and images downloaded and examined.

Every image from every camera was assessed for animals. Where an animal was found, the species, number of individuals and corresponding camera type, photograph number, time, date and other metadata were recorded.

All photographs have been archived on disc (even if no animals were present) for future reference.

Not all cameras were set to take three triggers. Many of the UoVision Pandas did not last the four-week survey period in round one as they appeared to be more sensitive than the other camera types and were activated more often by false triggers. In subsequent rounds, this camera type was set to take one photo per trigger only to overcome this. Data analysis was limited to one photo from each trigger for all camera types to allow easy and consistent comparison between camera types, rounds and treatments.

All data were managed within Microsoft Excel.

Species Groupings

It was expected that habitat linkages would be used more by some animal groups or size classes than others, so some species were grouped for some analyses. Additionally, if an animal in a photo was not identifiable to species (e.g. when only part of an animal was visible) but the animal could confidently be assigned into a size group (e.g., kangaroo - large and medium mammals) then these images were also used. The following groupings were made:

Table 2 Fauna groupings used for analysis

Group name	Fauna included in group
Large and medium mammals	Common Wombat, Eastern Grey Kangaroo, Black Wallaby, Short-beaked Echidna
Small mammals	Long-nosed Bandicoot or smaller e.g. rodent spp. antechinus spp. etc[3]
Large birds	Australian Magpie, Currawong spp. Raven spp. White-winged Chough, Grey Shrike-thrush, Bronzewing spp., Rosella spp., Lyrebird.
Small birds	Robin spp., Superb Fairy-wrens, Thornbill spp., Pardalote spp., Finch spp., Quail spp.
Possums	Common Ringtail Possum, Common Brushtail Possum
Reptiles	Snake spp., skink spp.
Fox/Cat	Red Fox, Cat
Unknown	Animal could not be identified even to group level.

Species grouped as ‘unknown’ were removed from analyses of photos with the exception of total numbers of images that contained an animal.

Two non-native species are assessed and presented separately rather than in groups (European Rabbit and Sambar Deer).

[3] NB that rodents and antechinus are likely to be in the photos but were not identified to species level (with the exception of one House Mouse) and are therefore not included in the species tally/list but it is clear that species of this size class were present and have been grouped within small mammals to include them within the analysis.

3. Results

A total of 227,232 images were taken by the 18 cameras over the course of the project; of these 7500 images included animals. Ultimately, after the removal of multiple photos from the same trigger (as determined by image time-stamps), 2706 images of animals were accepted for analysis Table 3 and Figure 3.

Overall (i.e., for all four sampling rounds), more photos of animals were captured by ADJ cameras (1112) than any other treatment type (19% more than CWD and 38% more than ROW).

In the two 2013 rounds comparable numbers of photos of animals were captured (867 and 814). Similarly, comparable numbers of photos of animals were captured in the two 2015 rounds, but the numbers of images in those latter rounds were considerably lower (512 and 514). In the first three rounds, numbers of images of animals were lower in the ROW than in the CWD or ADJ. In the final round, numbers of images of animals were higher in the ROW than in the CWD or ADJ.

Table 3 Total no. of photos with animals per treatment/round

Sampling round	Treatment			Total
	ADJ	CWD	ROW	
Feb '13	434 (50%)	235 (27%)	197 (23%)	**867**
Nov '13	298 (37%)	317 (39%)	199 (24%)	**814**
Jan '15	235(46%)	174 (34%)	103 (20%)	**512**
Apr '15	145 (28%)	176 (34%)	193 (38%)	**514**
Total	**1112**	**902**	**692**	**2706**

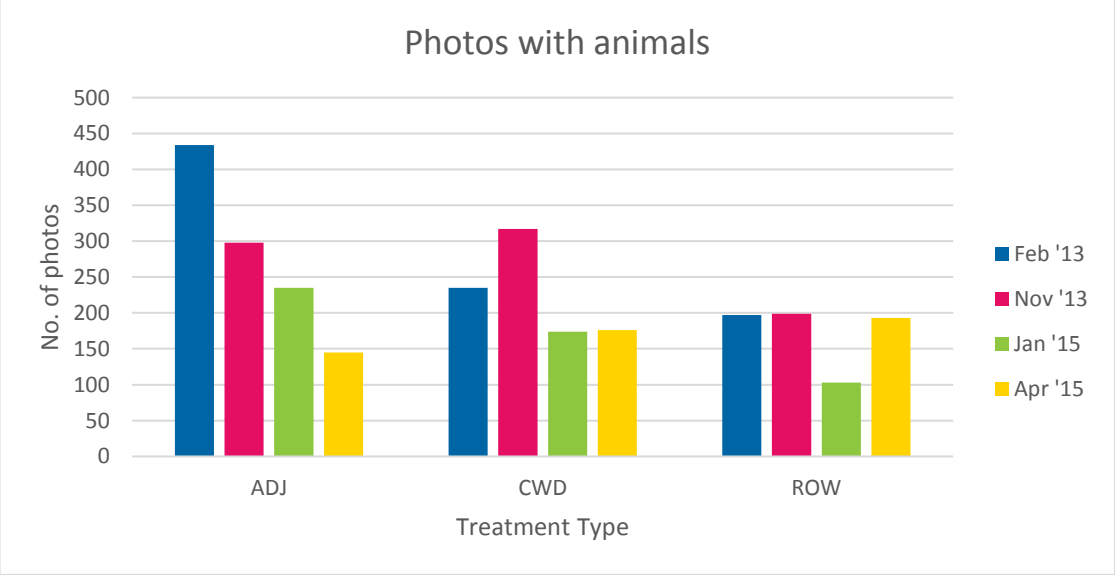

Figure 3 Count of total photos with animals per treatment/round

Whilst the ADJ treatment resulted in more photos of animals overall (1112, Table 3), more species were detected in the CWD (29[4]) than in the other treatments (Table 4 and Figure 4). A total of 34 species were identified from the photos (Table 4). Fewer species were observed during the 2015 rounds compared to the 2013 rounds.

Table 4 Total no. of species per treatment/round

Round	Treatment			Total
	ADJ	CWD	ROW	
Feb '13	12	16	13	**24**
Nov '13	17	17	13	**22**
Jan '15	14	14	7	**16**
Apr '15	8	12	8	**13**
Total	**21**	**29**	**20**	**34**

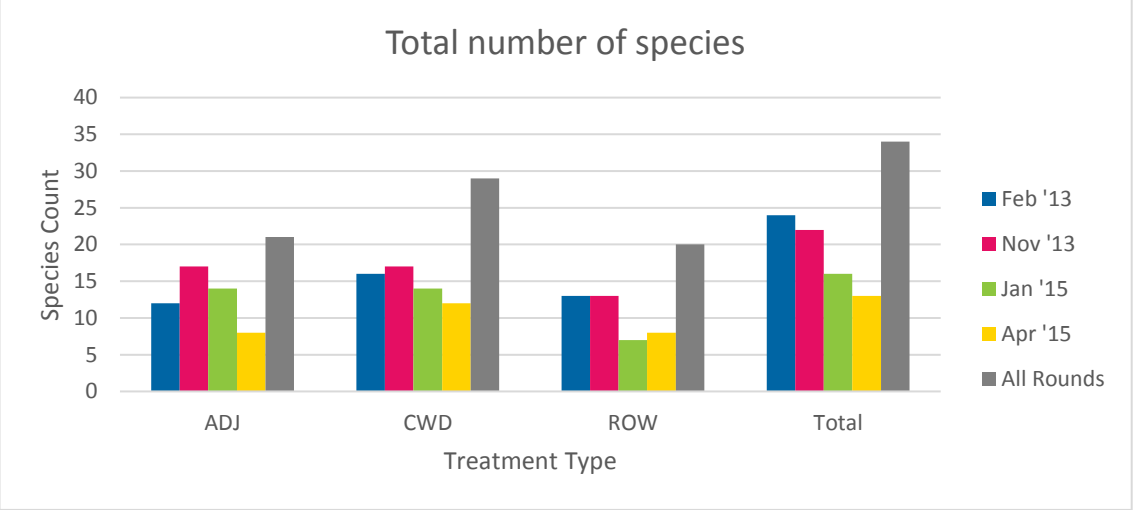

Figure 4 Number of species per treatment type

[4] Note animals that could not be identified to species level were not included in this analysis.

Species captured over the course of the project are detailed within Table 5. More species were unique to the CWD treatments (i.e. found within this treatment type only (Figure 5).

Table 5 Species per treatment type

Common Name	Scientific Name	ADJ	CWD	ROW	Total
Mammals					
Black Wallaby	*Wallabia bicolor*	478	172	104	754
Common Brushtail Possum	*Trichosurus vulpecula*	2		1	3
Common Ringtail Possum	*Pseudocheirus peregrinus*	3	1		4
Common Wombat	*Vombatus ursinus*	64	52	55	171
Eastern Grey Kangaroo	*Macropus giganteus*	27	18	32	77
Long-nosed Bandicoot	*Perameles nasuta*	54	1	2	57
Short-beaked Echidna	*Tachyglossus aculeatus*	11	6	7	24
Brown Hare*	*Lepus capensis*		1		1
Cat*	*Felis catus*	8	6	10	24
European Rabbit*	*Oryctolagus cuniculus*	262	157	363	782
House Mouse*	*Mus musculus*		1		1
Red Fox*	*Canis vulpes*	16	36	11	63
Sambar*	*Cervus unicolor*	11	10		21
Birds					
Australian Magpie	*Gymnorhina tibicen*	16	52	59	127
Brown Quail	*Coturnix ypsilophora*		1		1
Brush Bronzewing	*Phaps elegans*	5			5
Common Bronzewing	*Phaps chalcoptera*	1	6	5	12
Crimson Rosella	*Platycercus elegans*		4	1	5
Eastern Spinebill	*Acanthorhynchus tenuirostris*	1			1
Eastern Yellow Robin	*Eopsaltria australis*		6		6
Grey Currawong	*Strepera versicolor*		7		7
Grey Shrike-thrush	*Colluricincla harmonica*	2	3	1	6
Hooded Robin	*Melanodryas cucullata*		1		1
Pied Currawong	*Strepera graculina*	5	2	8	15
Raven Sp.	*Corvus sp.*	1	17	6	24
Red-browed Finch	*Neochmia temporalis*		4	1	5
Scarlet Robin	*Petroica phoenicea*		4	1	5
Superb Fairy-wren	*Malurus cyaneus*	27	89	24	140
Superb Lyrebird	*Menura novaehollandiae*	1			1
White-browed Scrubwren	*Sericornis frontalis*	8	6		14

Common Name	Scientific Name	ADJ	CWD	ROW	Total
White-Winged Chough	*Corcorax melanorhamphos*	6	15	1	22
Reptiles					
Common Blue-tongued Lizard	*Tiliqua scincoides*		1		1
Skink spp.		1	151	2	154
Southern Water Skink	*Eulamprus tympanum tympanum*		4		4
Tiger Snake	*Notechis scutatus*			1	1
Total		**1010**	**834**	**695**	**2539**

* Introduced

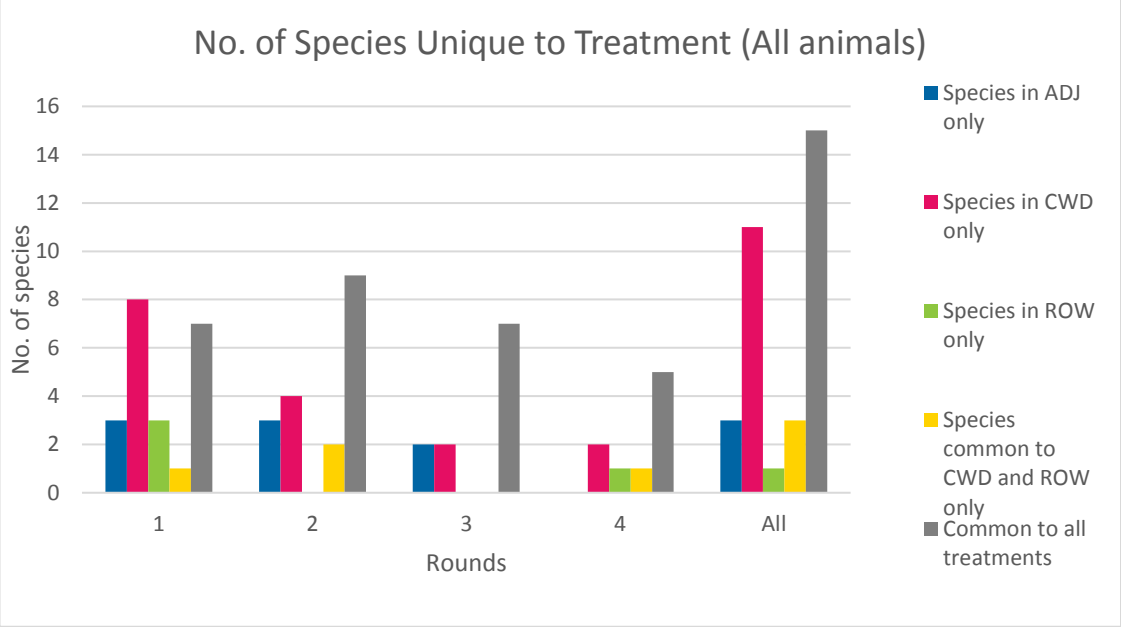

Figure 5 Number of species unique to treatment types

Species were grouped by size of animal and/or type of animal, and treatment types compared over time (i.e. rounds) (see Table 2). The following figures (Figure 6 to Figure 13) display these results.

Reptiles were only captured within the 2013 rounds and favoured CWD (Figure 6). Numbers of both the small mammal and large and medium mammal group photos declined over time but were consistently higher in ADJ treatments (Figure 7 and Figure 8). More photos were captured of both small and large bird groups in the more open treatments (i.e. CWD and ROW) (Figure 9 and Figure 10). Whilst the sample size is small (21), no deer were captured within the ROW (Figure 11). Cat and Fox numbers were fairly consistent over time with the exception of one outlier of 33 photos in CWD in Jan 2015 (Figure 12). Rabbits occurred in all treatment types over all rounds (Figure 13). Only 11 photos of possums were captured so have not been graphed below.

Habitat and vegetation assessments were not conducted as part of the project, but habitats were repeatedly photographed as part of the project. The following plates demonstrate the type of vegetation changes that occurred over the course of the project. **Plate 4**, **Plate 6** and **Plate 8** show examples of each of the treatment types during February 2013 (Round 1) compared to the same camera location in April 2015 (Round 4) in **Plate 5**, **Plate 7** and **Plate 9**.

Plate 4 CWD Treatment Area 1 – Feb ’13 CWD Treatment Type

Plate 5 CWD Treatment Area 1 – Apr ’15 CWD Treatment Type

Plate 6 CWD Treatment Area 2 – Feb ’13 ROW Treatment Type

Plate 7 CWD Treatment Area 2 – Apr ’15 ROW Treatment Type

Plate 8 CWD Treatment Area 3 – Feb ’13 ADJ Treatment Type

Plate 9 CWD Treatment Area 3 – Apr ’15 ADJ Treatment Type

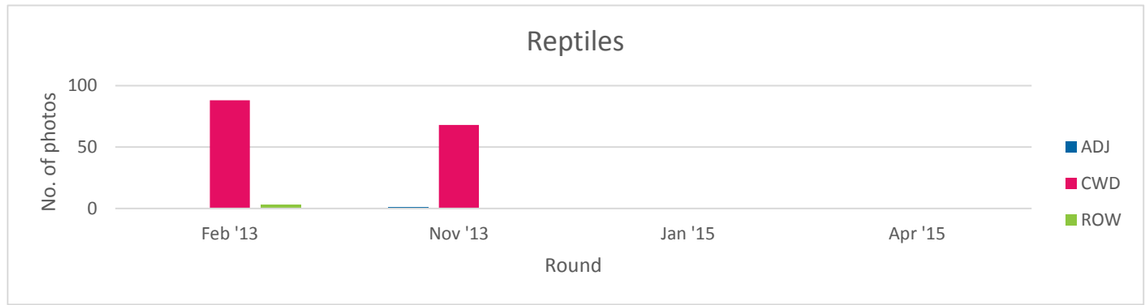

Figure 6 No. of photos of reptiles per round

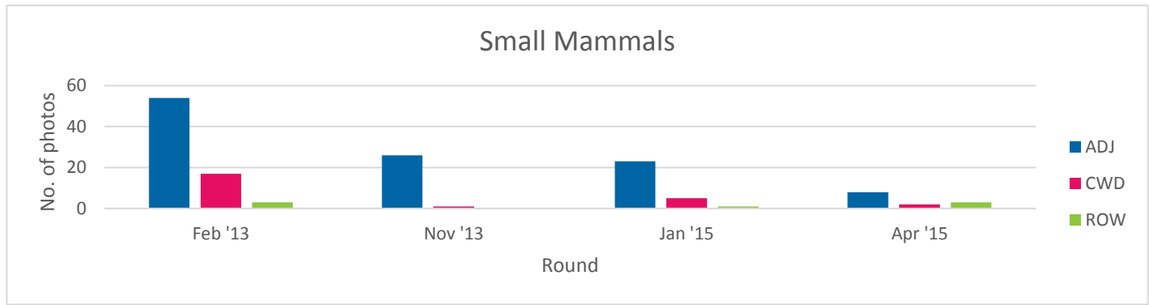

Figure 7 No. of photos of small mammals per round

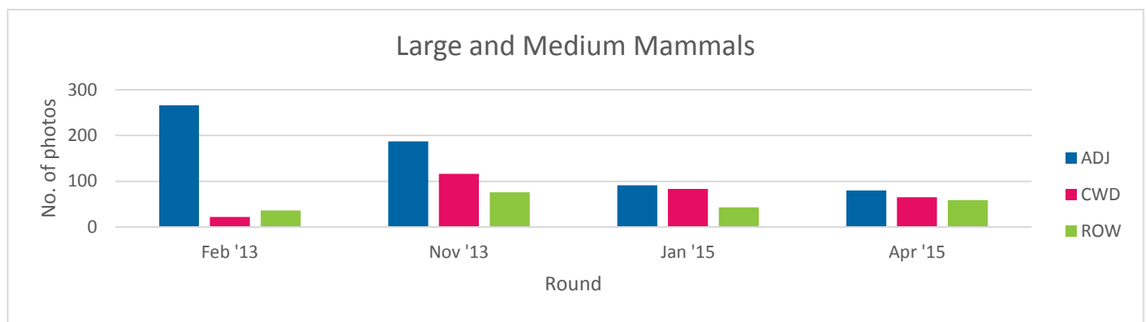

Figure 8 No. of photos of large and medium mammals per round

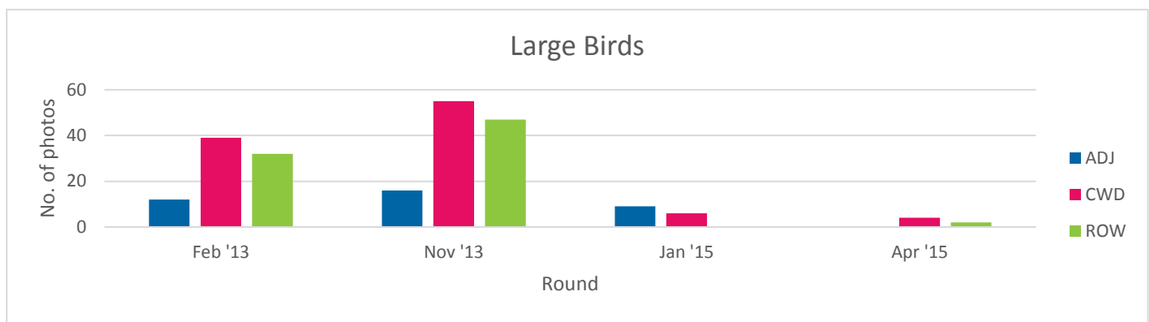

Figure 9 No. of photos of large birds per round

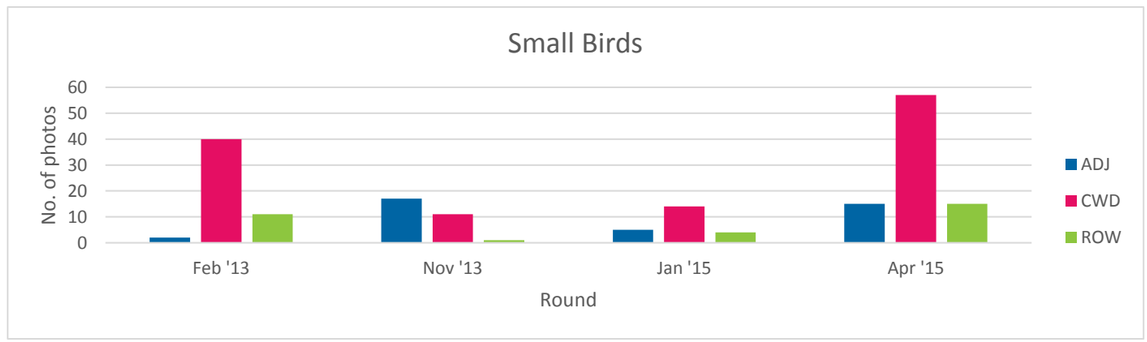

Figure 10 No. of photos of small birds per round

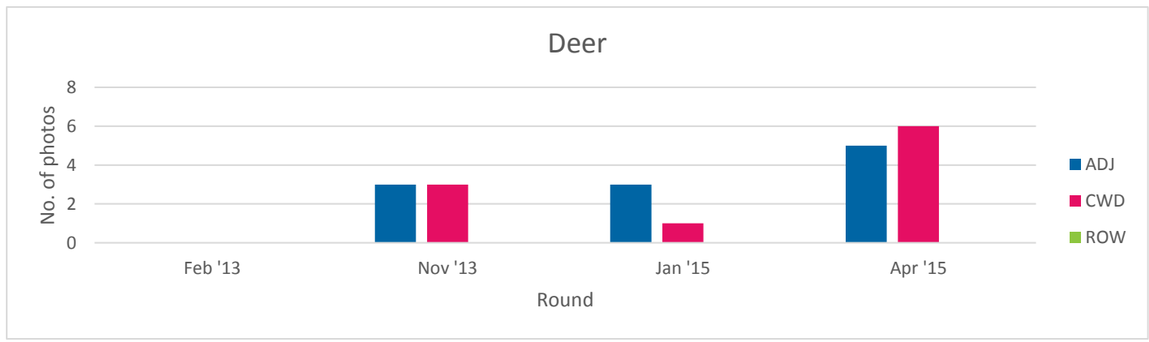

Figure 11 No. of photos of deer per round

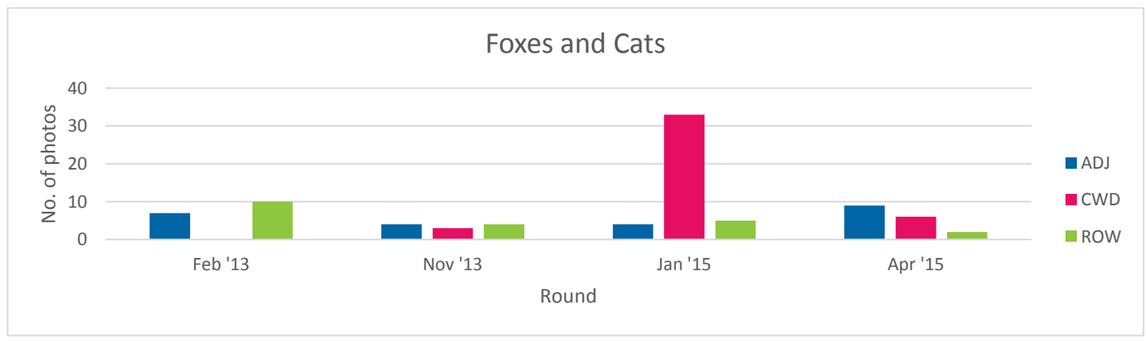

Figure 12 No. of photos of foxes and cats per round

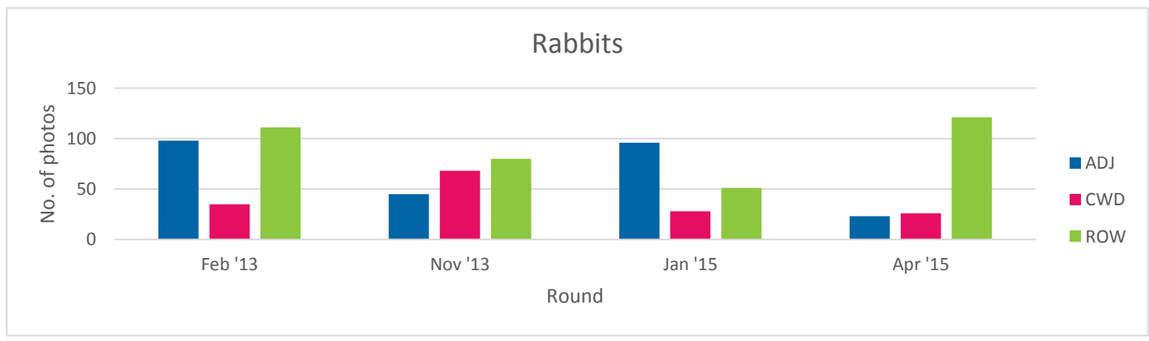

Figure 13 No. of photos of rabbits per round

4. Discussion and Conclusions

Only 3.3% of photos taken over the course of the project contained animals. The remaining photos are false triggers predominantly caused by vegetation moving in the wind and changes in shadow. This demonstrates some of the issues faced with camera sensitivity and inherent challenges with a camera survey in this type of forested environment. The bulk of the effort with a project of this nature is not the experiment itself but the time involved in processing the images/data.

A total of 2706 photos of vertebrate animals from 34 species were captured with more photos of animals captured from the ADJ treatment compared to the other treatment types and during 2013 rounds compared to the 2015 rounds. Whilst it is interesting to note the large volume of photos captured during the course of the project and the disparity between years and treatment types there are several factors that complicate the comparison of numbers of photos of animals. Namely, there were several types of cameras used, each with a different level of sensitivity, and each of the four rounds were of slightly different durations. These variables are somewhat offset however by the fact that camera types were dispersed amongst treatment types and rounds so variation in round duration or camera sensitivity for an individual camera is absorbed by the rest of the data.

Additionally, it is not possible to discern the number of individuals detected by the cameras. Despite removing incidences of multiple triggers (i.e. analysis included a single photo from each trigger only), any given individual may have triggered the camera more than once in succession and/or on multiple days, thereby being repeatedly photographed. However, the numbers of images represent an “activity” index and indicator of habitat use rather that providing empirical data on individuals using treatment types. Potentially more useful information can be drawn out by looking at numbers of species and types of fauna that used the treatments over the course of the project.

A total of 34 vertebrate fauna species were captured during the course of the project (13 mammals, 18 birds and three reptiles). When comparing the number of species within each treatment for each round, the difference is typically of only a few species (0-4), yet the CWD treatment consistently had the highest or equally highest species count. Over the course of the project, the highest species count was also in the CWD treatment. These results are influenced by the detection of species that were seen once over the whole project (e.g. Brown Hare, House Mouse, Brown Quail, Eastern Spinebill, Hooded Robin, Superb Lyrebird, Common Blue-tongue Lizard and Tiger Snake). Of the eight species recorded once only, five were found in the CWD treatment only. All species that were unique to a particular treatment occurred in small numbers, and given their typical behaviour and habitat use, would be expected to utilise at least one, if not both, of the other treatments. It is likely that the CWD treatments are capturing a combination of the forest (ADJ) fauna and cleared habitat (ROW) fauna. Twelve species (35.3% of all species) were detected in CWD and/or ROW treatments, but not in the adjacent forest (ADJ). This suggests that the complement of fauna that uses the area has been influenced by the initial clearing of the ROW; some non-forest species may have colonised the area because of the newly cleared ROW.

The total number of species captured in each round decreased over time (range 24 – 13), however, this is not surprising given the accompanying decrease in photos of animals over time (range 867 – 512). Proportionally there are similar numbers of species per image in 2013 as 2015.

CWD linkages are likely more important to some species or groups of species than others. For example, large bold birds such as Australian Magpie, Ravens and Currawongs are unlikely to require such linkages to help them cross the cleared alignment and here were shown to use the cleared areas (ROW-81 and CWD-105) more than the forest area (ADJ-37). However, small potentially vulnerable birds are expected to require some habitat in place to allow them to cross an open area while avoiding predation. So rather than using species as a means to measure the success of the CWD linkages, species groups (i.e., by size and type) are thought to provide a more informative picture.

The use of particular treatment types by fauna is expected to change as the vegetation grows and establishes over the duration of the project. Comparing initial 2013 images and later 2015 images, it is apparent that the vegetation in the ROW and CWD treatments changed over time. Vegetation in those treatments grew taller and denser over the course of the project. This variable is likely to affect particular fauna groups in different ways; for example, as the vegetation becomes denser, small mammals may use the ROW as well as the CWD, as both treatments now have cover. Similarly, as the vegetation becomes denser, detection of reptiles may decrease as they become harder to detect and/or basking opportunities reduce over time.

The reptile group consisted almost entirely of images of small skinks. Of 160 records all were found within the CWD treatment with the exception of four. Relative to other treatments, the CWD is expected to provide the unique combination of basking opportunities (the forest canopy has been cleared) with safe refuge nearby (the added logs). However, these results may be skewed by the ecology of this group in that they tend to have small home ranges and repeatedly use the same basking locations for an extended period (therefore resulting in larger numbers of images per repeated visit by the same individual). Skinks would be expected to use the ADJ however cameras were typically set up in small clearings (to minimise false triggers) to increase the field of view, which are unlikely to be preferred by small skinks despite the ADJ habitat overall being suitable for this group. Only one sighting of a reptile was made in the ROW; Tiger Snake, a species that may not require shelter in order to cross the cleared alignment. Typically, CWD may have provided shelter and habitat for the reptile group that was not otherwise available within the cleared alignment (ROW). Numbers of images of this fauna group might have been expected to decrease over time as the vegetation becomes denser, however, many of the images within the CWD treatment were of individual skinks basking on top of, or within the end of logs, and detections of this nature are not expected to be influenced by changes in the surrounding vegetation. It is possible that, given the likely small number of individuals making up the number of reptile images, that predation of individuals could play a part in the decrease in this group between 2013 and 2015.

Numbers of photos of small mammals and large and medium mammals both declined over time but were consistently the highest in the ADJ and consistently lowest in the ROW. This is expected for small mammals such as the Long-nosed Bandicoot and rodent spp, who were predicted to be the group that would benefit most from the CWD linkages, but was not expected for large and medium mammals such as wallabies, wombats, kangaroos etc as CWD in principle could have caused a barrier to their movement. It is also possible that the logs and large timber present in the CWD treatment prevented those areas from becoming overgrown with larger shrubs. This may reduce the grazing potential of the treatment for some fauna, and in the later rounds of the project may have offered a food resource that was diminishing from the ROW treatments while the CWD treatments offered both grazing and browsing potential.

Both the small and large bird groups appear to favour the CWD treatment over the ROW. Whilst the number of large bird detections were higher within the CWD than the ROW within all rounds, the values were similar (biggest disparity only eight photos). Large birds may not rely on CWD as they can easily cross the cleared alignment without the addition of habitat features. However, the CWD offers resources that are different/absent from the ROW such as shelter and food and whilst this group can easily cross the cleared alignment resources may attract it to the CWD treatment. Small birds favoured the CWD but there was a bigger disparity between the CWD and ROW treatments. Whilst this group is unlikely to need the CWD to cross the cleared alignment, the CWD contained foraging resources and habitat features that the ROW lacked e.g. perches and moist shady areas under logs, which promotes invertebrate activity.

Deer were detected in small numbers over the project (total 21), and were never recorded within the ROW, which is surprising given this species both grazes and browses. Prior to the analysis of images, the CWD was expected, if anything, to create a physical hindrance to the species, but the data collected here suggest that was not the case. There is no clear explanation for the disparity between the treatments and it may just reflect the small sample size.

Numbers of foxes and cats were fairly equal between the treatment types with the exception of the Jan 2015 round where there were more than three times the number seen than in any other treatment in any given round. While multiple triggers of the same animal may account to some degree for this disproportionate increase, photos of cats and foxes were captured from five of the six CWD cameras set up in the round, which demonstrates that these animals were widespread in the area, and not just frequenting one camera or location in particular. As opportunistic hunters, foxes and cats are unlikely to need this habitat feature to cross the cleared alignment, but they may favour the CWD habitat if it provides better habitat for their prey items. The decrease in small mammals and rabbits in the later rounds may correspond with the increase in predators. The disparity between the number of images of predators within cleared treatments and the ADJ is unlikely to be sufficient to indicate that clearing of the pipeline has increased the numbers of non-native predators and therefore exacerbated a Flora and Fauna Guarantee Act 1988 “Key Threatening Process”.

Rabbits were the second most abundant species in photos behind the combined large and medium mammals (782 and 1124 photos respectively). Rabbits were found across all three treatments, but showed a fairly clear preference for the ROW over the CWD treatments. More CWD throughout the alignment is unlikely to reduce numbers of this pest however, as it is possible that the logs and large timber present in the CWD treatment will prevent areas from becoming overgrown with larger shrubs and therefore maintaining a grazing resource within the treatment.

Whilst some of the small mammals identified in the CWD and ROW treatments may be Long-nosed Bandicoots, of the photos that could be definitively identified as this species and not just this size group; only 5% (three images) of individuals were found in the CWD and ROW. Contrastingly, a direct competitor of the Long-nosed Bandicoot, the European Rabbit, thrived in the cleared treatments (CWD and ROW combined made 65% of images of this species). Both Long-nosed Bandicoot and small mammals were detected almost entirely in the ADJ, therefore regardless of the presence of CWD the initial clearing does appear to have created a barrier to movement for these types of species. As both the ROW and the CWD are relatively narrow (i.e. east-west across the cleared alignment) it is also possible that there are fewer images in these treatments of Long-nosed Bandicoot and small mammals as a result of an edge effect compared to the ADJ treatment which were set up approximately 50 m away from the cleared treatments. That is, it’s not that they don’t prefer one of the cleared treatments (CWD or ROW) over the other but are barely leaving the forest at all.

The data are complex and likely to be influenced by many variables, including (but not limited to): different numbers of images per sampling round, multiple types of cameras used with varying sensitivity, different duration of rounds and changes in seasonality between rounds. Data here are presented in raw form without standardisation.

There are many more questions to investigate to be able to understand whether CWD habitat linkages are an effective means of mitigation to allow some or all fauna to use or cross the cleared alignment, but which would require additional investigation. For example:

- Are small mammals not leaving the forest due to an edge effect of the forest with the CWD treatment, as opposed to the CWD being entirely unsuitable? Would a broader linkage of CWD allow more mammals to cross?
- Is CWD more effective in areas where the clearing was wider i.e. the ROW spanned 30 – 60 metres? No discrete linkages were studied within this project in areas where the clearing was of 60 m width.
- Given the existing location of the Melba Highway, is there a similar suite of species in the ADJ forest on both the east and west side of the cleared alignment?

In conclusion, based on the data collected for this project, while some fauna species appeared to favour CWD over ROW habitats, no clear benefit for the CWD treatment was evident. This may be an artefact of small sample sizes (potentially made up of repeat individuals) and animals preference to stay in the forest than attempt to cross the cleared alignment via the ROW or CWD rather than the CWD treatments providing no assistance to animals once they do leave the forest. The numbers of small mammals and Long-nosed Bandicoots (the key species predicted to benefit from the CWD linkages) that ventured outside of the ADJ into either the CWD or ROW were small (approximately a third of total captures within the ADJ) and the effort to construct the CWD may not warrant the benefit in this scenario where there is ample intact forest still present. Had the project been established sooner after the installation of the pipeline (2010) before any reinstatement or natural regeneration had begun the results may have been drastically different; as vegetation was already present at all of the treatments rather than being able to compare the CWD to the ROW in the absence of other habitat features.

If anything, as told by the proportionally large number of species found solely within the CWD, the CWD treatment may have created an additional habitat type, rather than linking adjacent forest patches with equivalent forest habitat.

In order to prove the effectiveness of the CWD as a habitat linkage, the survey method would require review (i.e. use of radio-tracking or GPS techniques) and would require monitoring over a greater period of time. Additionally, statistical analysis of the data collected during this project is expected to help strengthen these conclusions.

Appendices

Appendix A – Sample photos

Long-nosed Bandicoot (Round 1 – ADJ)

Long-nosed Bandicoot (Round 1 – ADJ)

Tiger Snake (Round 1 – ROW)

Short-beaked Echidna (Round 2 – ROW)

Black Wallaby (Round 2 – ADJ)

Eastern Grey Kangaroo with Joey (Round 2 – ADJ)

Fox with small mammal prey (probably Rabbit) (Round 2 – ROW)

Sambar Deer (Round 4 – ADJ)

Scarlet Robin (Round 4 – CWD)

Southern Water Skink (Round 1 – CWD)

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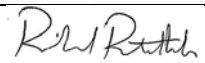
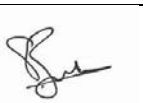
0	Kelly Dalton	Richard Retallick		Steven Brattle		31/05/17

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