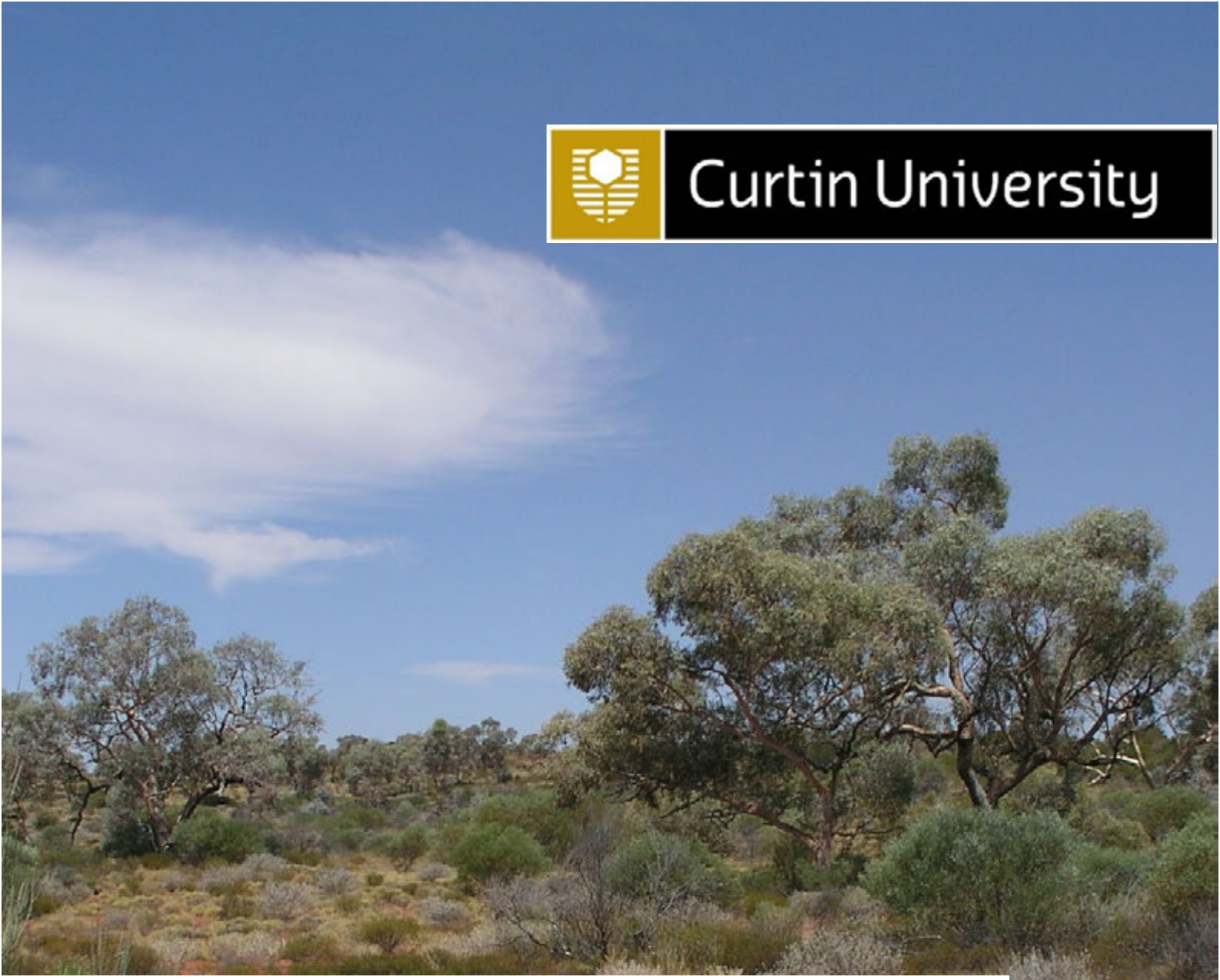

Camera trap image collation and species analysis within Great Victoria Desert Landscape Conservation Initiative areas (GVDBT research areas)

Prepared by: Mark Cowan
School of Molecular and Life Sciences, Curtin University

Curtin would like to pay respect to the Aboriginal and Torres Strait Islander members of our community by acknowledging the Traditional Owners of the land on which the Perth campus is located, the Whadjuk people of the Noongar Nation; and the Wongutha people of the North-Eastern Goldfields on which our Kalgoorlie campus is located. We acknowledge the Traditional Owners, their ancestors, Elders, and emerging for their stewardship of Country.

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REPORT INFORMATION

- Project Name: Camera trap image collation and species analysis within the Great Victoria Desert landscape conservation initiative area.
- Date of report completion: 11th January 2024
- Report Author(s): Mark Cowan, Curtin University
- Project Proponent(s): Great Victoria Desert Biodiversity Trust Management Panel

KEY FINDINGS

- There is limited power from the current camera arrays to determine the effectiveness of any future management actions beyond the control of species such as camels or dogs/dingos.
- The assemblages of mammal fauna off-track in the management area and reference area are markedly different. From the perspective of using cameras in the current array, the reference area is not a particularly good analogue of the management area.
- There were relatively few detections of species of conservation significance.
- Poor deployment of a significant number of cameras has negatively impacted the amount of useful information obtained in this project.

CONTEXT

The Great Victoria Desert Biodiversity Trust (GVDBT) installed 96 remote camera traps between the 3rd and 6th May 2022 in two separate areas in the Great Victoria Desert (GVD), each approximately 30 km by 30 km, and identified as the reference area (RA) and the management area (MA). The RA is adjacent to the south-western boundary of Plumridge Lakes Nature Reserve while the MA is around 23 km from the eastern boundary of Queen Victoria Spring Nature Reserve. The north-eastern corner of the MA is approximately 20km from the south-western corner of the RA. The purpose of these two areas is to provide an opportunity to undertake and monitor experimental landscape-scale manipulations in the MA, including changing fire regimes and predator management, while the RA would be used as a control with no planned intervention. The use of cameras in these areas is to help provide a baseline understanding of biodiversity attributes in both areas with a particular focus on introduced predators, introduced herbivores and conservation-significant species, particularly malleefowl and sandhill dunnarts. The arrangement of cameras in each of the areas is 25 infrared flash cameras set along the edge of tracks at a spacing of >3 km and 23 white flash cameras set off tracks in long unburnt vegetation at a spacing of >1.5km. Data were intended to be downloaded from cameras regularly however due to unforeseen difficulties in accessing the areas, the first round of data was not collected until late August 2023, some 16 months after the cameras had initially been set.

This report summarises the collation of these data including an overview of target species such as conservation significant species and introduced mammals. In addition to the summary report, an Access database is provided containing details of, and links to, collated camera trap imagery. In addition to the database, a link to a web-based application that allows for visual spatial and temporal interrogation of the data (Cowan 2017) will be provided temporarily.

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DATA COLLATION

Camera trap data were provided on a hard drive with a single folder for each of the 96 cameras. The duration of the deployment of the cameras was approximately 475 days (3rd May 2022 to 24th August 2023). Collectively there were 135,116 images. These images were run through Megadetetcor AI software (Beery *et al.* 2019) using a 10% or greater probability of an animal being present to separate images with and without animals from one another. To ensure false negatives were eliminated from this process, images determined as false detections were subsequently scanned manually using FastStone Image viewer (FastStone 2023) and any containing animals were transferred back to the appropriate folders within the positive images. False positives did not require any intervention at this point as they are identified when imagery is entered into the database.

Invariably sequences of images that occur close together are the same individual, such as a kangaroo grazing in front of a camera, a dingo examining a camera or an individual of any species moving slowly through the camera detection zone. Therefore, time sequences were extracted from the embedded image EXIF data using the R statistical programming language (R Core Team 2023) to further subset images. This was done by selecting the single image with the highest probability of being an animal (from Megadetector) where each sequential image is taken less than 10 seconds apart from the previous one. This final subset of data was then uploaded to the database and the species for each image was identified, along with the details of which camera the image came from and the date and time of the image. When the capture of this subset of data was complete, the identification details were transferred back to the other images from the same time sequence and these data were then also uploaded to the database.

The database used for the capture and management of images and associated data was CPW Photo Warehouse, an open-source MS Access database (Newkirk 2016). This database is widely used for the capture, identification and management of camera trap imagery. It is also straightforward to use, maintains metadata for camera deployment timing, provides links to imported imagery and is capable of providing a wide range of reporting and data queries.

RESULTS- OVERVIEW

While the original number of images from all camera traps was 135,116, 76% of these (103,176) were false detections. False detections for each camera are shown in Figure 1.

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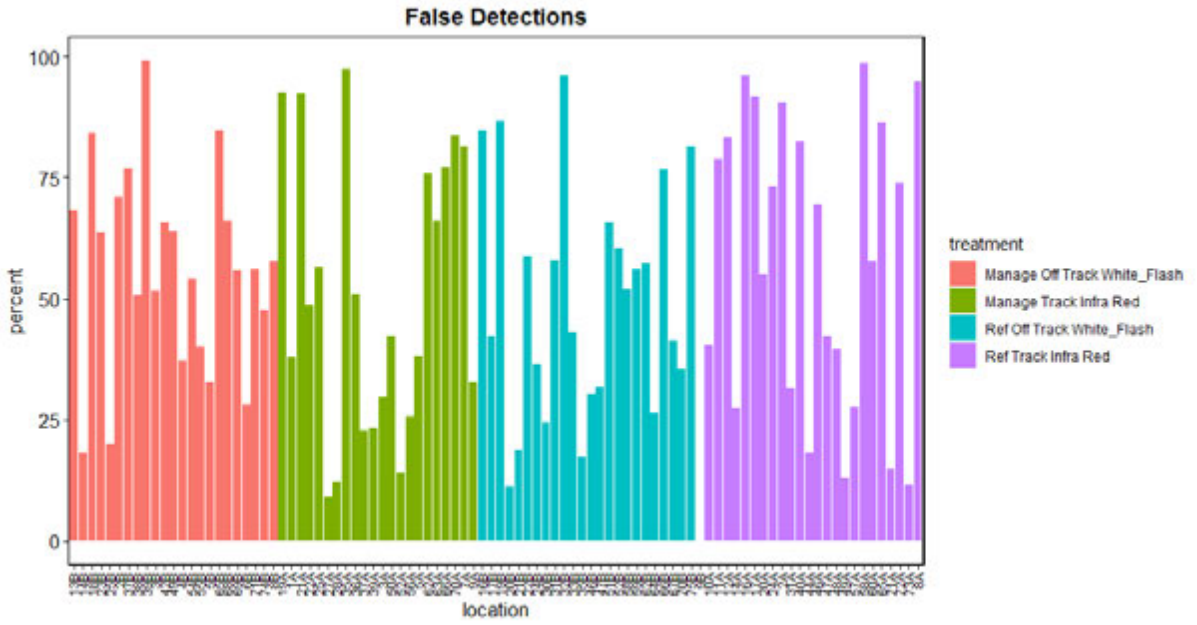

Figure 1 False detections as a percent of overall images taken for each camera.

A total of 31,913 positive detections occurred however a large number, 3,701 (13%), were of the people setting the cameras and thus there were only 28,212 images of fauna, Figure 2.

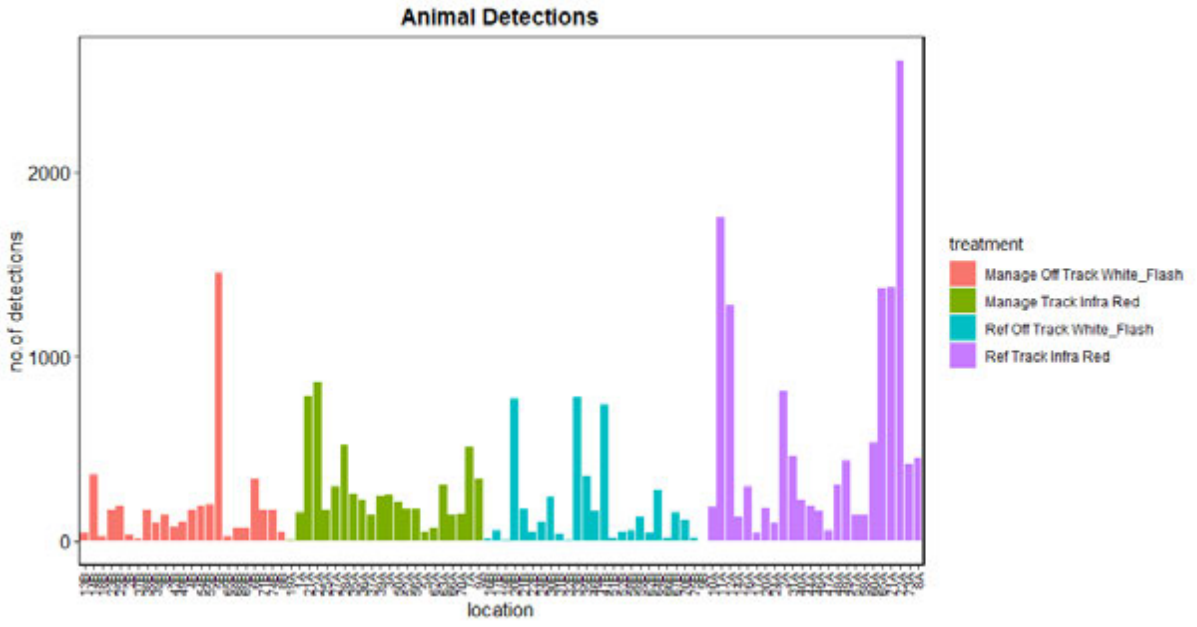

Figure 2 Number of animal detections for each camera.

Of the 96 cameras deployed, 52 had stopped operating before servicing in August 2023 and 15 of these had stopped operating before the end of 2022. The on-track infrared cameras in both the MA and RA had the shortest duration (Figure 3) with eight of the RA on-track infrared cameras having stopped working after less than 200 days. The majority of off-track white flash cameras remained operational throughout the 475 days of deployment with only six having stopped working before the 475 days.

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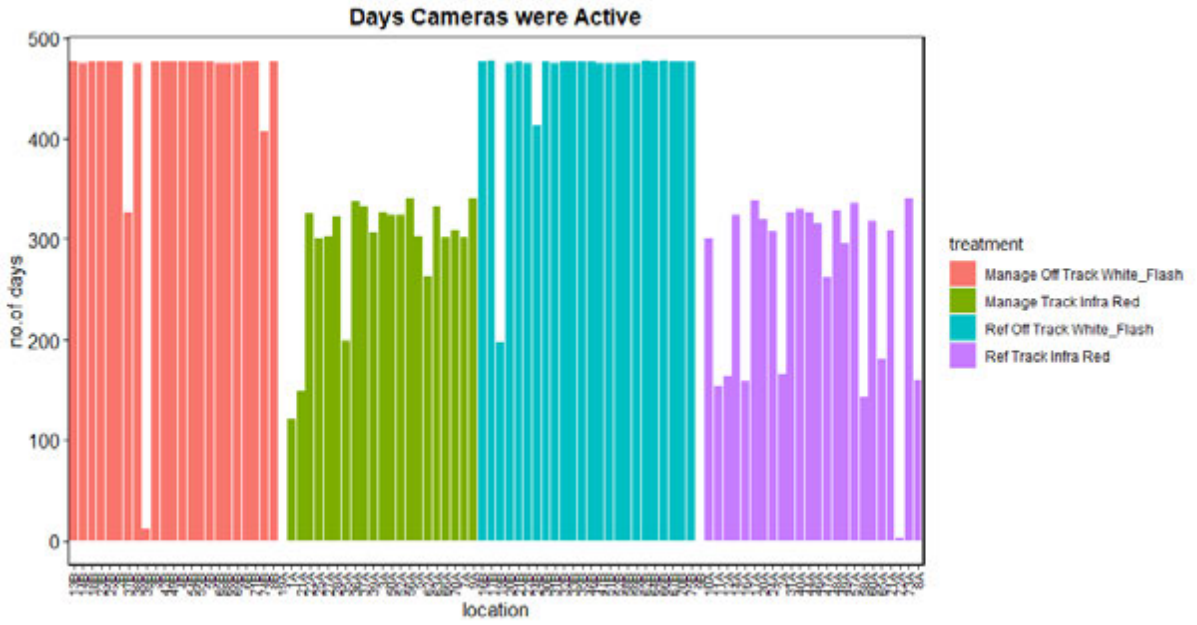

Figure 3 Number of days each camera was active.

RESULTS-ANIMALS

When assessing detections of species it is important to define what timing is used for independence of detection. Extensive analysis of camera trap datasets by the author has shown that for most species, particularly those that are not common or very abundant, using a single detection per camera per 24 hours is not significantly different from using intervals of one hour or even less, and for many species, there is no difference at all. This occurs because most animals do not repeatedly traverse the same area over short timeframes, and where there are multiple detections over short time frames, they are almost invariably the same individual(s). Consequently, for all information on detection rates within this report, 24 hours is used for independence unless otherwise stated. An assessment of these timeframes for target species from this project is provided in Figure 4.

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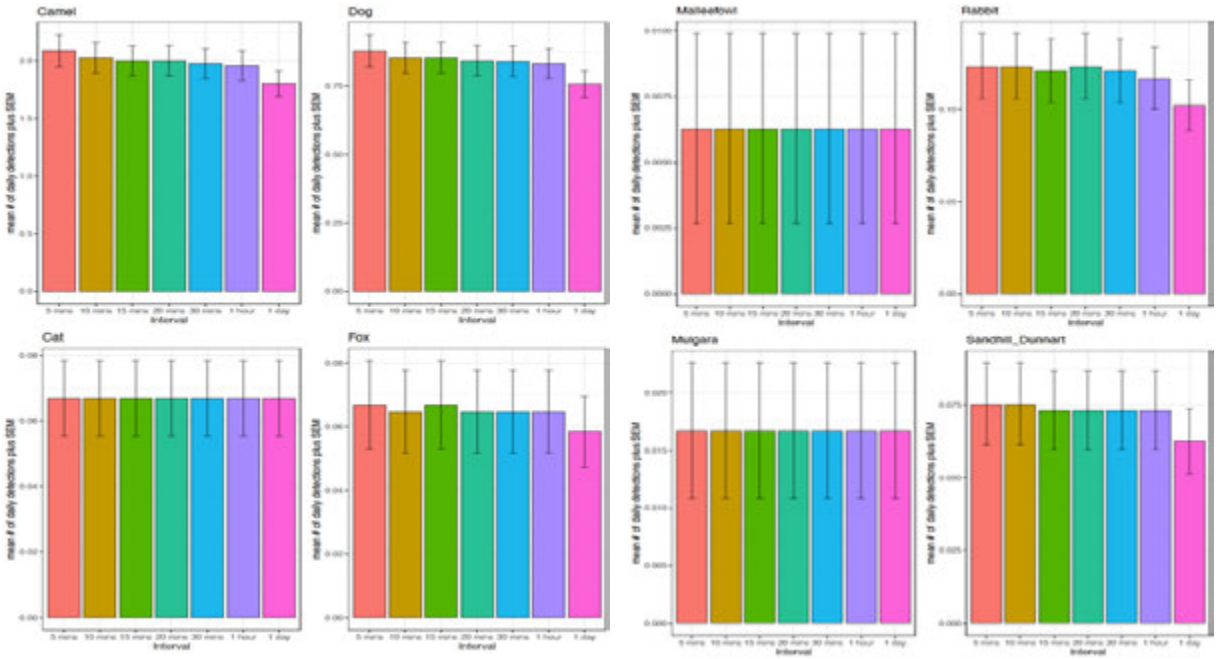

Figure 4 Example of difference in detection rates ranging from five minutes to 24 hours for four introduced species from this study.

There were 46 species identified from a total of 2295 independent images across the duration of the study and from all locations. These consisted of 6 reptile species, 25 bird species and 15 mammal species. A number of these species, particularly reptiles and small birds are not reliably detected with camera traps as their thermal signature and/or size is outside that which is consistently picked up by the camera's passive infrared sensor (PIR). While summary detection data for these are provided in the tables all reptiles and birds, other than the conservation significant malleefowl, are excluded from further analysis. Within the mammals, there were four introduced species (camel, feral cat, fox and rabbit) along with the dingo/wild dog. Only three conservation-significant species were detected and these were the malleefowl, brush-tailed mulgara and the sandhill dunnart, although there remains some uncertainty for some sandhill dunnart images as position and distance relative to the camera makes identification problematic in certain situations. This issue can also arise for other small species that do not have distinctive patterns or colouration, especially where infrared camera flash is used. Table 1 provides an overview of all independent detections for all species and from which areas of the study areas they occurred.

Overall species richness is markedly higher off-track in both the RA and MA compared to on-track cameras, as would be expected. Camels and dingos/dogs had significantly higher detection rates on-track vs off-track and while camel detections were comparatively similar between the RA and the MA, dingos/dogs were detected almost twice as often in the RA. Feral cat detections were comparatively few in all areas although detections were higher off-track, particularly in the MA. Foxes were only detected in the RA with the majority of these on-track. Rabbits were only detected off-track and all but one of these detections were in the RA.

There was a total of three detections of malleefowl, all in the MA, with two on-track and one off-track. There were eight detections of mulgara and these were at three locations, all off-track in the MA. Sandhill dunnarts were detected 30 times off-track in the MA with 28 of these on consecutive days at a single location and the other two at one other location. Some caution is required for these detections due to the difficulties of identification from imagery.

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Table 1. Detections of fauna that were identified from camera traps on track and off track in both the management area and the reference area. This covers the entire time camera were in the field.

Common Name	reference area off track	management area off track	reference area on track	management area on track	Total
Bearded Dragon	1	5			**6**
Black Tree Monitor	2	7			**9**
Bustard				1	**1**
Camel	7	4	589	495	**1095**
Cat	7	16	6	3	**32**
Chestnut-breasted Quail-thrush	7	1		1	**9**
Chestnut-rumped Thornbill		1			**1**
Crested Bellbird	18	15	2		**35**
Crested Dragon			1		**1**
Crow				1	**1**
Currowong	18	61	1	2	**82**
Dog	18	2	247	126	**393**
Echidna	2	1	1		**4**
Emu				3	**3**
Euro	21		1	2	**24**
Fox	3		25		**28**
Gilberts Whistler		1			**1**
Goulds Sand Goanna	17	17		2	**36**
Grey Butcherbird	9	6	1		**16**
Grey Kangaroo	52	52	50	23	**177**
Grey Shrike-thrush	2				**2**
Hairy-footed Dunnart	14	4			**18**
Hooded Robin		3			**3**
Magpie	1	3	1	1	**6**
Malleefowl		1		2	**3**
Mulgara		8			**8**
Ningaui	2	29			**31**
Ooldea Dunnart	16	7			**23**
Owlet Nightjar	1	1			**2**
Pied Butcherbird	4	1			**5**
Pygmy Desert Monitor	1	2			**3**
Rabbit	48	1			**49**
Red-capped Robin	1				**1**
Redthroat	1				**1**
Sandhill Dunnart *		30			**30**
Sandy Inland Mouse	3	60			**63**
Short-tailed Grasswren		1			**1**

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Common Name	reference area off track	management area off track	reference area on track	management area on track	Total
Spinifex Hopping Mouse	68	1			**69**
Splendid Fairy-wren	2				**2**
Spotted Nightjar	1	1			**2**
Striated Pardalote	1				**1**
Tawny Frogmouth	1	1			**2**
Thorny Devil	2	4			**6**
Wedge-tailed Eagle		1			**1**
White-browed Babbler	2	1			**3**
Yellow-throated Miner	1	5			**6**
Total	**354**	**354**	**925**	**662**	**2295**

Images of conservation significant species and their detection locations are provided below. The size of the green circles are the relative numbers detected at each location and their scale differs between the different species plots. Numbers on the plots are camera location numbers rather than details about species numbers.

A summary of the proportion of cameras (expressed as a percentage of total number of cameras) that each species was detected on, both on-track and off-track for the RA and MA is presented in Table 2. The majority of species were detected on relatively few cameras with only camels, dogs/dingos and grey kangaroos captured on more than 50% of the cameras, having detections of 59%, 54% and 67% respectively. However, for on-track detections, camels were caught on 100% of cameras in both the RA and MA while dogs/dingos were caught on 87% in the RA and 86% in the MA. Grey kangaroos had comparatively high detections both on and off track for both the RA and MA and ranged from 43% on-track in the MA to 83% on-track in the RA. Foxes were only recorded on 8% of cameras, all in the RA, cats on a total of 17% across all areas and rabbits 4%, all off-track. For the species of conservation significance sandhill dunnarts were only caught on 2% of cameras (Figure 5), mulgara on 3% (Figure 6) and malleefowl 2% (Figure 7).

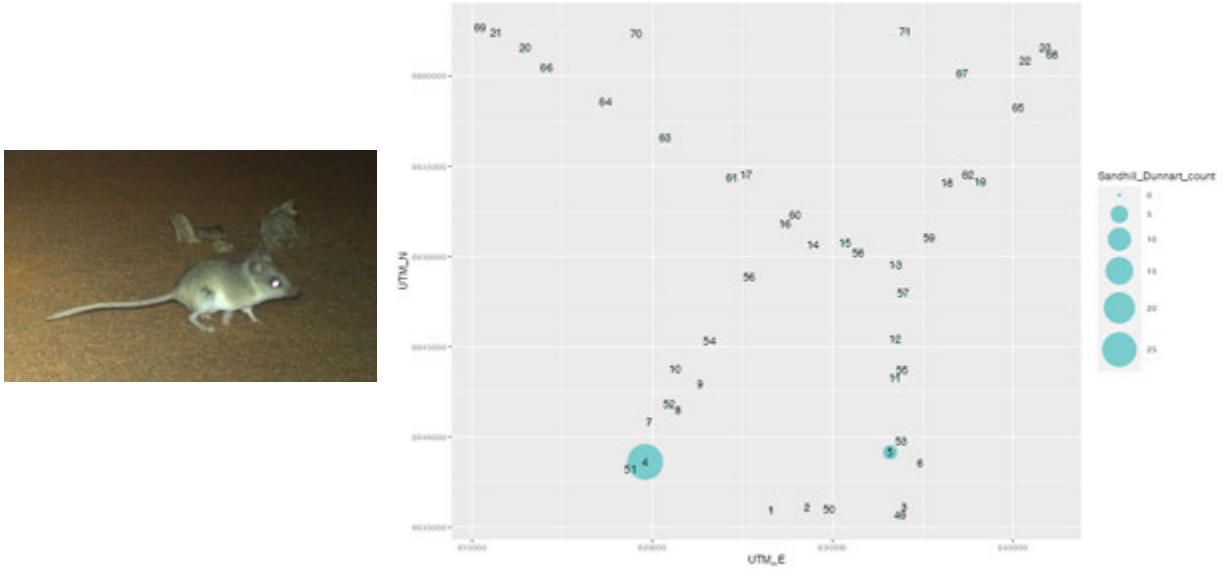

Figure 5 Sandhill dunnart image along with detection locations within the MA

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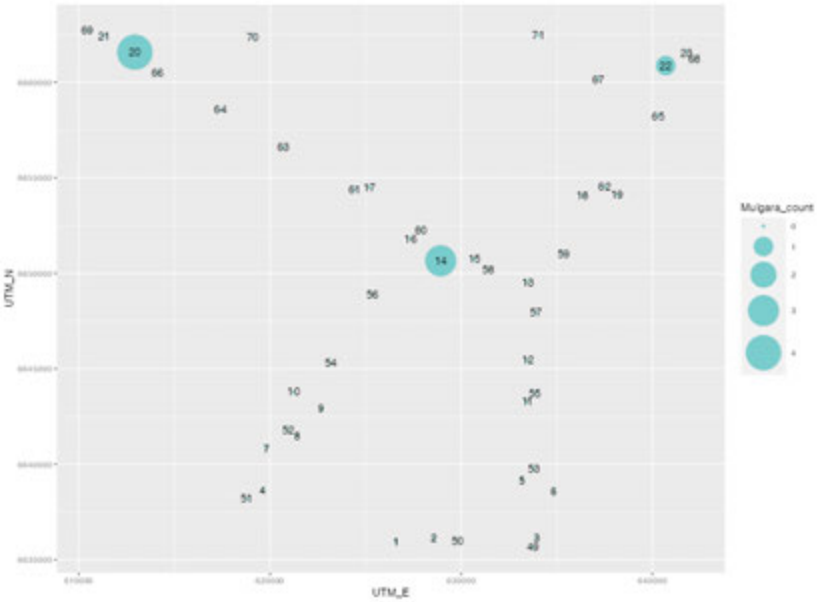

Figure 6 Mulgara image along with detection locations within the MA

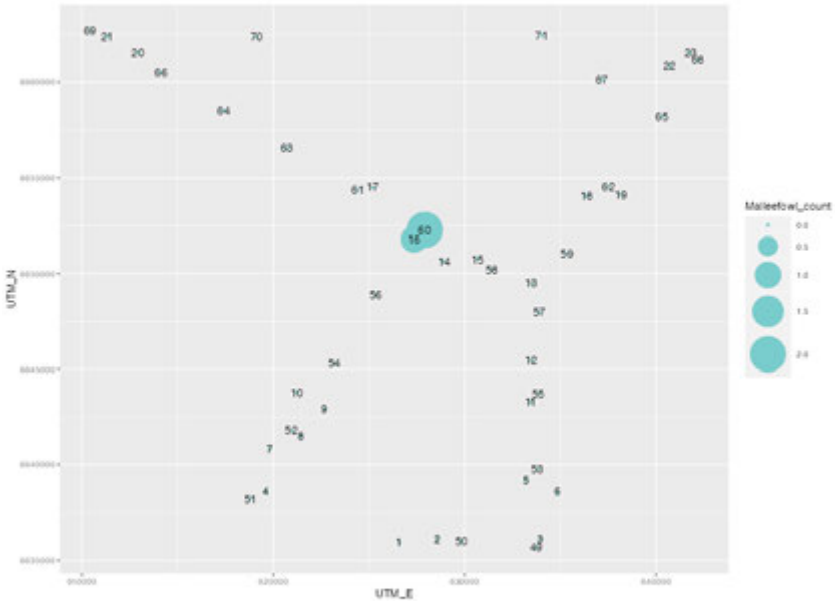

Figure 7 Malleefowl image along with detection locations within the MA

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Table 2. Proportion of cameras within the different areas that each species was detected on. This covers the entire time cameras were in the field.

Common Name	reference area off track	management area off track	reference area on track	management area on track	Total
Bearded Dragon	4	14	0	0	**4**
Black Tree Monitor	8	32	0	0	**10**
Bustard	0	0	0	5	**1**
Camel	21	18	100	100	**59**
Cat	13	36	13	5	**17**
Chestnut-breasted Quail-thrush	25	5	0	5	**9**
Chestnut-rumped Thornbill	0	5	0	0	**1**
Crested Bellbird	33	36	4	0	**19**
Crested Dragon	0	0	4	0	1
Crow	0	0	0	5	1
Currowong	25	41	4	5	19
Dog/Dingo	42	5	87	86	54
Echidna	8	5	4	0	4
Emu	0	0	0	14	3
Euro	21	0	4	5	8
Fox	13	0	17	0	8
Gilberts Whistler	0	5	0	0	1
Goulds Sand Goanna	29	45	0	10	21
Grey Butcherbird	25	23	4	0	13
Grey Kangaroo	63	77	83	43	67
Grey Shrike-thrush	8	0	0	0	2
Hairy-footed Dunnart	8	9	0	0	4
Hooded Robin	0	5	0	0	1
Magpie	4	9	4	5	6
Malleefowl	0	5	0	5	2
Mulgara	0	14	0	0	3
Ningaui	8	36	0	0	11
Ooldea Dunnart	25	14	0	0	10
Owlet Nightjar	4	5	0	0	2
Pied Butcherbird	13	5	0	0	4
Pygmy Desert Monitor	4	5	0	0	2
Rabbit	13	5	0	0	4
Red-capped Robin	4	0	0	0	1
Redthroat	4	0	0	0	1
Sandhill Dunnart	0	9	0	0	2
Sandy Inland Mouse	4	27	0	0	8

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Common Name	reference area off track	management area off track	reference area on track	management area on track	Total
Short-tailed Grasswren	0	5	0	0	1
Spinifex Hopping Mouse	21	5	0	0	7
Splendid Fairy-wren	8	0	0	0	2
Spotted Nightjar	4	5	0	0	2
Striated Pardalote	4	0	0	0	1
Tawny Frogmouth	4	5	0	0	2
Thorny Devil	8	9	0	0	4
Wedge-tailed Eagle	0	5	0	0	1
White-browed Babbler	8	5	0	0	3
Yellow-throated Miner	4	18	0	0	6

Spatial representation of distributions and detection rates for introduced species in both the RA and MA, where species occur in both, are shown in Figures 8 through 10. As the fox and rabbit were predominantly detected in the reference area there is only a single map for each, Figures 11 and 12 respectively.

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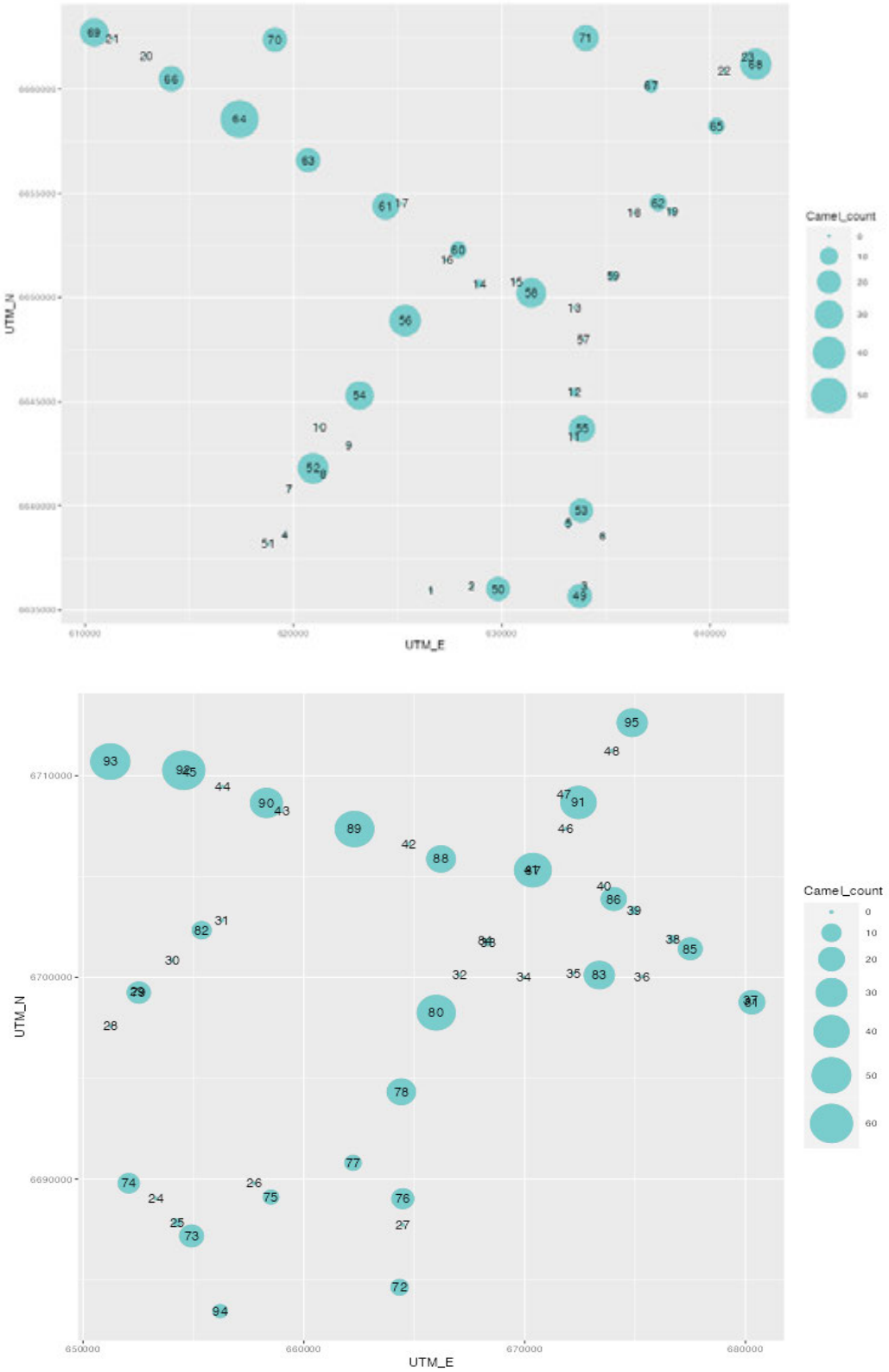

Figure 8 Camel detections in the management area (top) and the reference area (bottom)

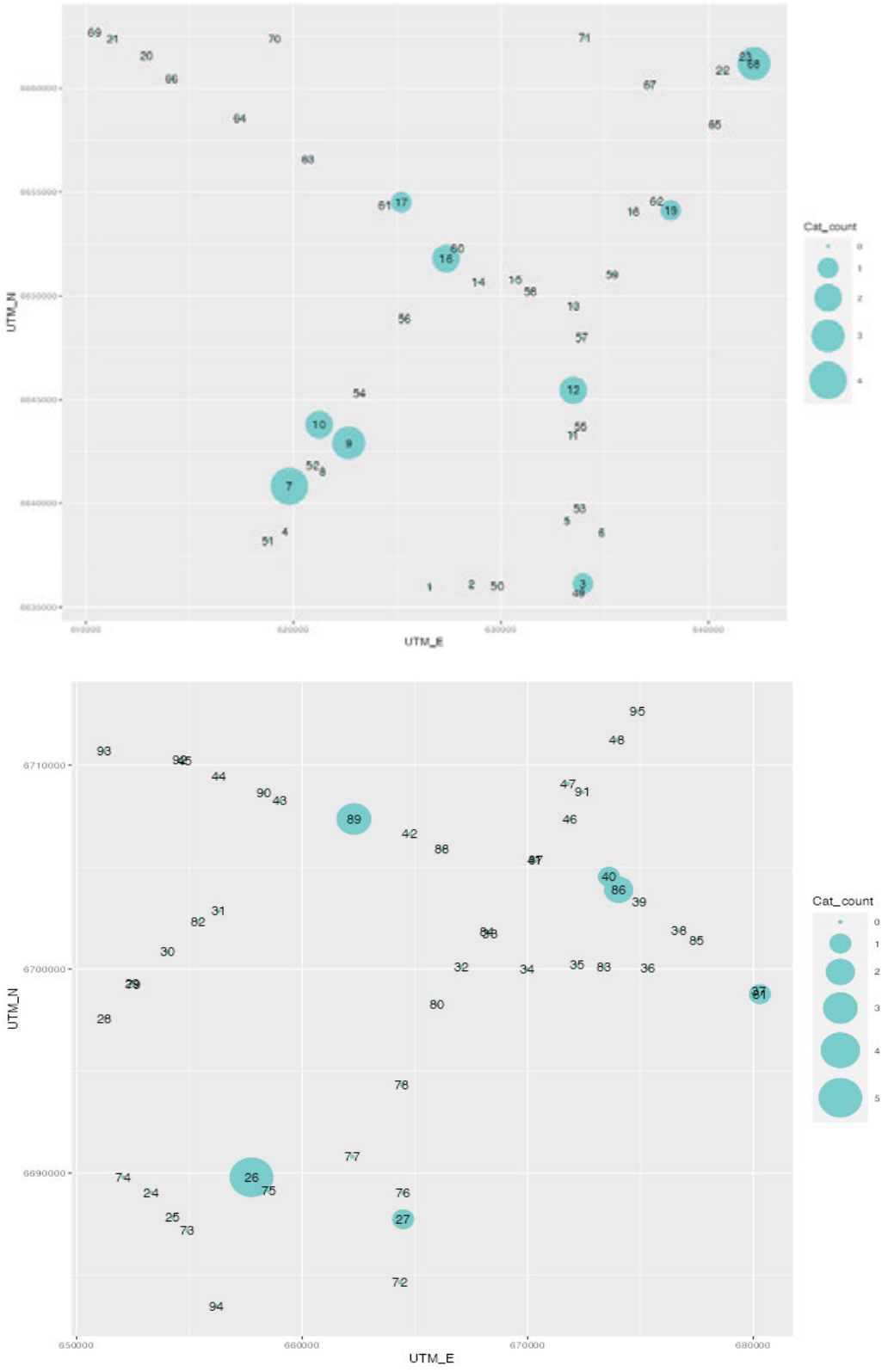

Figure 9 Feral cat detections in the management area (top) and the reference area (bottom)

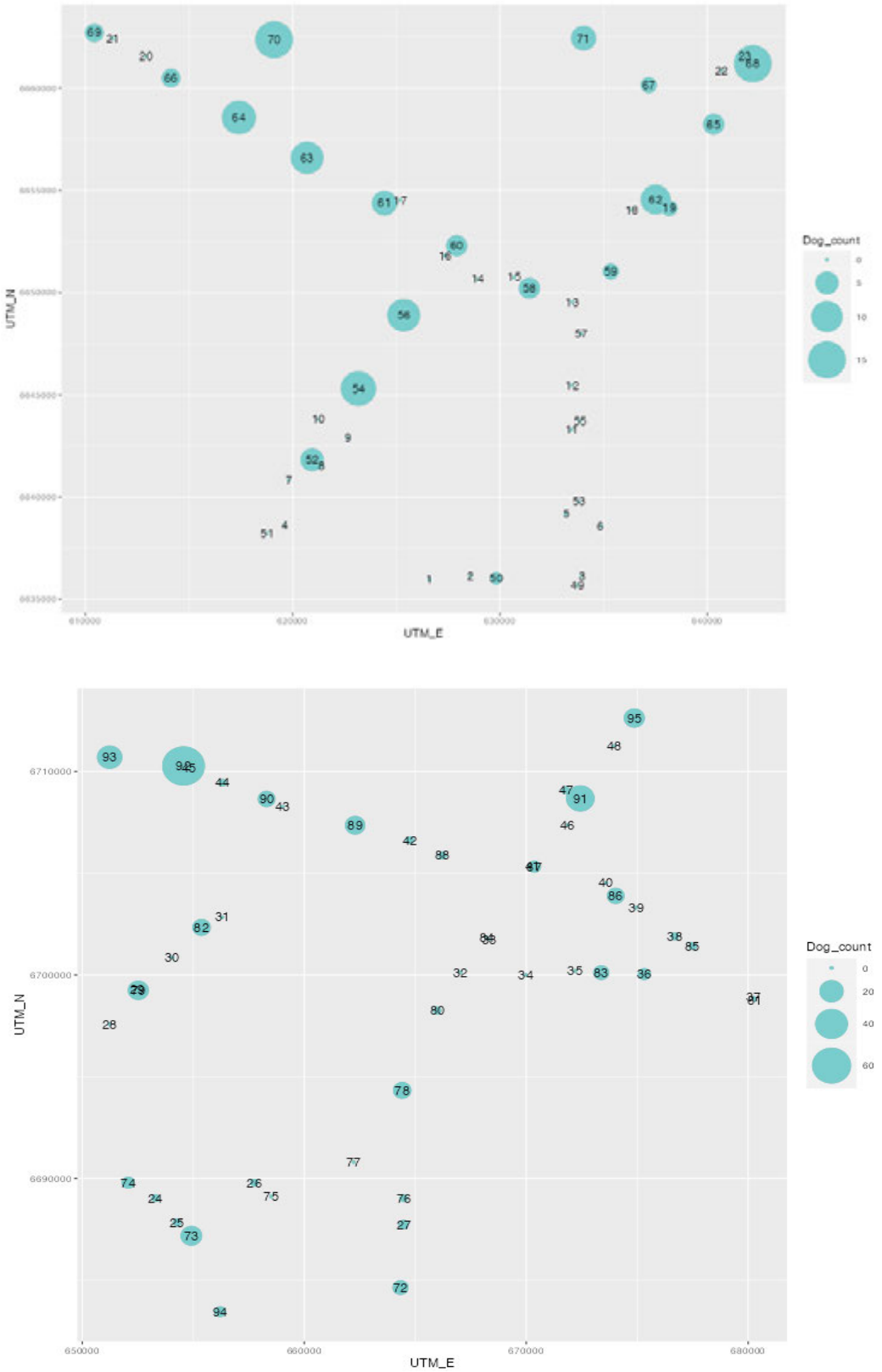

Figure 10 Dog/dingo detections in the management area (top) and the reference area (bottom)

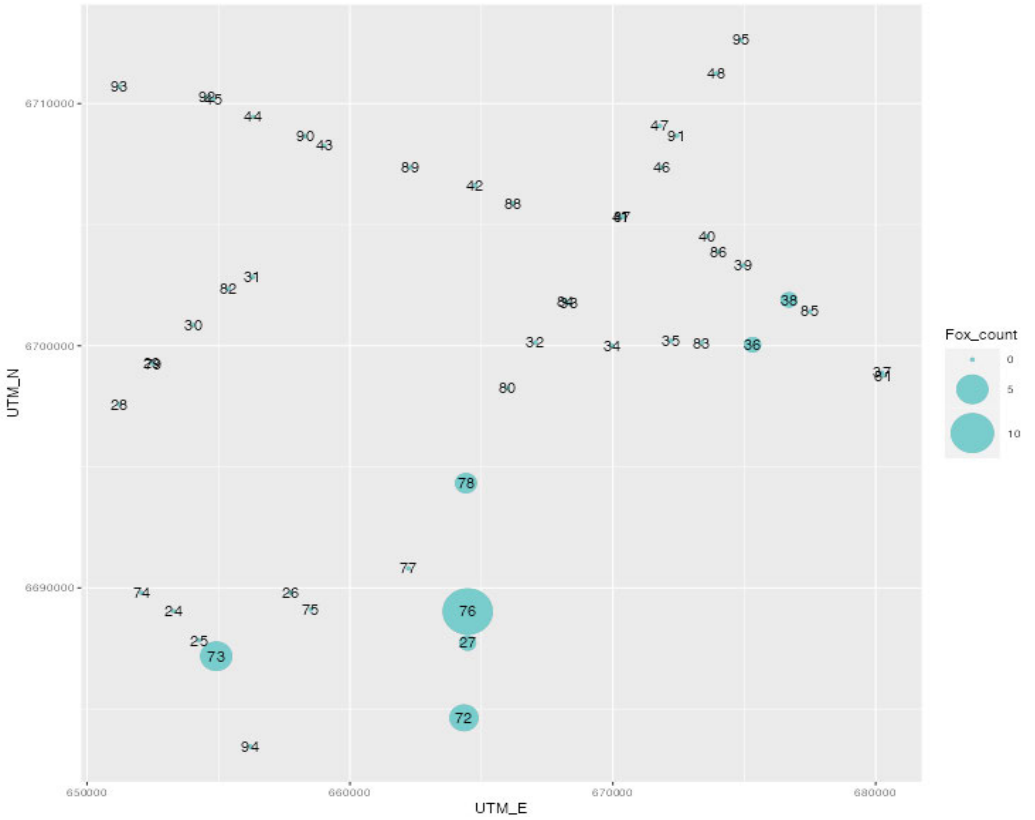

Figure 11 Fox detections in the reference area

Figure 12 Rabbit detections in the reference area

DISCUSSION

While 95 cameras have been deployed for 475 days there are several issues identified here that present problems for analysis. Firstly, batteries in a significant number of cameras went flat long before they were serviced. This failure rate was most notable for the infrared flash cameras placed on track. This presents an issue for analysis of on-track data as meaningful comparison can only occur for the time that all cameras, or at least the vast majority, were operating. In this case, data from only 150 days or approximately 31% of the time the cameras were deployed in the field could be used for comparative analyses.

Several things contribute to rapid battery drain and therefore early failure in cameras and these include poor battery quality, one or more damaged cells reducing overall capacity, mixing of battery types/models, wrong battery setting, using batteries that were not fully charged, false detections, and unnecessary imagery taken by switching the camera on before having it set in position. While the specific issues causing battery drain cannot be determined here, the 76% of images being false detections vastly exceeds the rate from similar projects and could be a key contributing factor. The mean number of false detections per camera was 54% (± 26) whereas for similar camera trap projects such as one undertaken at Dragon Rocks Nature Reserve (similar vegetation structure, camera model and set up) the mean number of false detections per camera is 24% (± 16), less than half this rate. These false detections in the GVD project occurred primarily because vegetation was too close to the camera and within the field of view of the PIR sensor. Secondarily, most cameras had been switched on before having been placed in position meaning a significant number of images (>13% of the positive detections) were taken of the operator or during the setup process. Collectively these add to the drain on batteries and contribute to the early failure of cameras. False detections also result in SD cards filling early and importantly, add significantly to the time and cost of subsequent data capture and analysis.

There were several other inconsistencies with camera setup including five cameras being set to time-lapse and taking an image every 30 minutes (all on-track within the RA and all having gone flat by October 2022) and one camera set to take an image every five seconds with its batteries flat only 10 days after having been set. Some off-track cameras were set with obstructions in the field of view while others faced north resulting in image flare during the day or false triggers from the sun. Obstructions in particular, or distance from dense vegetation, as well as often contributing to increased rates of false detections, have negative implications on the detection area as it varies from one camera to another and as a consequence so do the number of potential animal detections. The preferred direction to face cameras in the southern hemisphere is in a southerly direction where possible.

Overall the camera trap deployment has provided information on the prevalence and distribution of a range of species, particularly camels, dogs/dingos and kangaroos, and to a lesser extent feral cats and foxes, however for most species, and notably those of conservation significance, there is not enough data for any statistically robust assessments. While the amount of useful data was likely reduced by the settings and early failure of a number of cameras, a power analysis test indicates that even if cameras had functioned for the entire duration there would still likely be a paucity of data for analysis in establishing any meaningful baseline information between the RA and the MA for many species, and for any analysis to assess the effectiveness of management actions. As an example based on cat detections for off-track cameras, with power of 0.80 for detecting a difference between means for the RA and MA

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using the one-tailed two-sample t test with a value of 0.05 for alpha, there would need to be an effect size of 0.86 to be confident management was causal. It will therefore be important to consider the purpose of the camera trap monitoring program and how this resource is best used in the longer term. There may be benefits in maintaining aspects of the design, providing deployment issues are dealt with, if the aim is to capture observational data on species and help to determine locations for other experimental activities.

In terms of overall mammal similarity between the RA and MA, on-track and based on the presence/absence of mammal data only, most sites (cameras) have an 80% or higher similarity with one another (Figure 13). This strong similarity is driven by low diversity and the occurrence of the most wide-ranging and common species, specifically camels and dogs/dingos.

Conversely for off-track cameras in the RA and MA, again based on presence/absence data for all mammals, there is a low similarity with most sites within the two groups having less than a 60% similarity with one another indicating that the overall species assemblages are moderately divergent (Figure 14). This is driven by several species being detected primarily only in either the RA or MA rather than being common to both. For example, sandhill dunnarts and mulgara were only detected off-track in the MA whereas the Ooldea dunnart and spinifex hopping mouse were both more widely distributed in the RA.

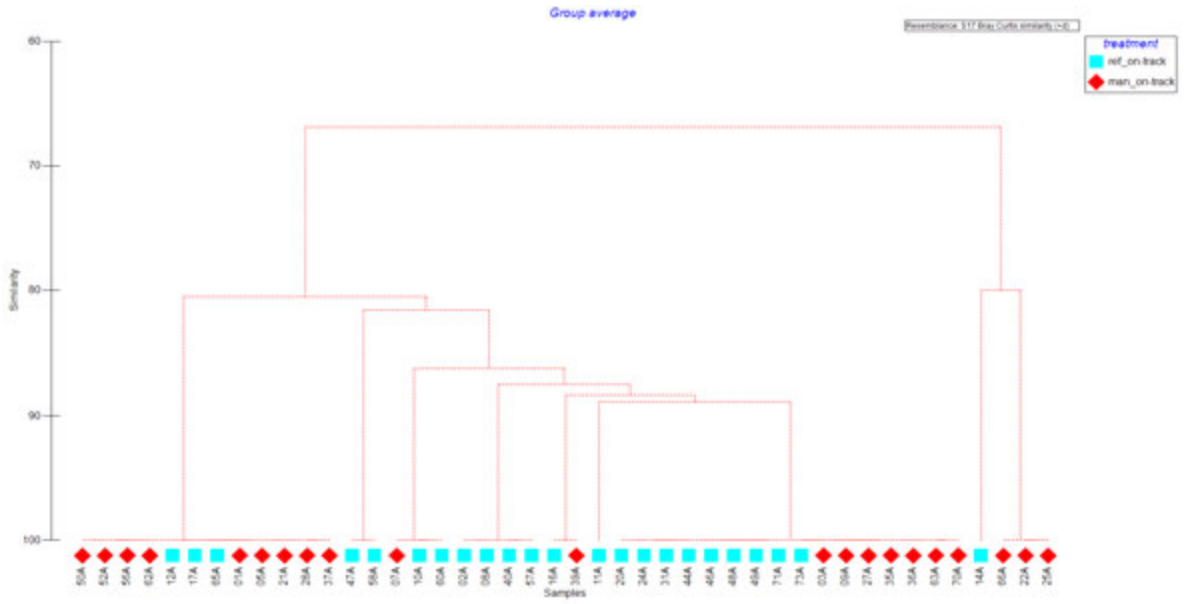

Figure 13 Similarity (Bray Curtis) of on-track cameras in the reference area and the management area based on the presence/absence of all mammal species detected.

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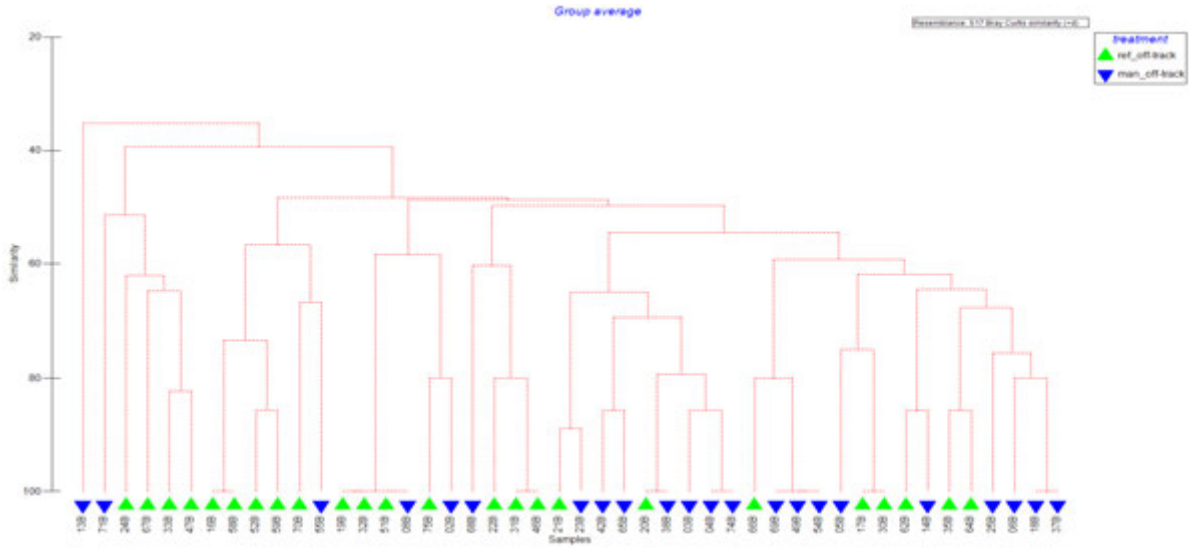

Figure 14 Similarity (Bray Curtis) of off-track cameras in the reference area and the management area based on the presence/absence of all mammal species detected.

RECOMMENDATIONS

There would be a benefit for the GVD Trust management panel to clearly define the purpose of the current use of camera traps in the RA and MA. If it is to provide baseline information to measure future management it is likely to be of limited value for all but the most widespread species such as camels and dingos/dogs. There would also be significant benefit in developing more rigorous and standardised protocols around the deployment of cameras to ensure consistency in data collection and to maximise the value and amount of useful data collected. To this end, the following are some general considerations for long-term camera trap deployments using still imagery.

- Set cameras at a standardised height (e.g. sensor ~350 to 400mm above ground level) using the same method of fixing- ideally fixed by an ¼ inch bolt to a 450mm plastic or metal tent peg (Figure 15, Appendix 1). Cameras should face south where possible.
- Ensure the detection zone is as large as possible with no close obstructions or moving vegetation in the field of view. In dense vegetation locations this may require minor removal of branches or waving grasses etc, although dense vegetation can often be avoided just by moving the camera a short distance away with no negative implication for experimental design.
- Camera settings must be consistent across all cameras e.g. 3 images per detection and no delay between detections, the same PIR sensitivity and ensuring time lapse/ video is off unless specifically required.
- It is usually desirable to have labels/ID's set on all cameras so images are stamped with this. This is the best way to ensure image data can always be traced back to an individual camera and its location.
- Preferred batteries are low self-discharge 2100 milliamp Fujitsu NiMH batteries. These replaced the original Sanyo Eneloop as Eneloop are now manufactured in China and no longer have the same low self-discharge technology as they originally had.
- Cameras should be in position and ready to operate before being turned on to avoid unnecessary triggers.

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- Servicing of cameras should occur at regular intervals and generally, no longer than 150 to 180 days, unless more modern Reconyx cameras are deployed as they are more battery efficient.
- A best practice is to use datasheets to record the deployment and servicing of cameras and an example is given-Figure 16, Appendix 1. Recording such things as time and date of setting along with battery status ensures that cameras are not inadvertently left off and also identifies where faulty batteries and or cameras may be an issue.
- As CPW Photo Warehouse has been set up for this project, this should remain the primary method for data capture and management to maintain longer term data consistency.

LITERATURE CITED

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ADDITIONAL INFORMATION

Links to online data interrogation application:

http://ningaui.ddns.net/apps/GVD/
http://ningaui.ddns.net/apps/GVD_Management/
http://ningaui.ddns.net/apps/GVD_Reference/

username: gvd
password: shd

APPENDIX 1

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Figure 15 450mm plastic tent peg showing mounting bolt (left) and mounted camera(right)

Camera Trap Data Sheet

Location:..... Date Set: / /

Site #	Camera #	Easting	Northing	Time Set	Date Recovered	% Battery Left	No. Images	% New Batteries	Comments

Figure 16 Example data sheet for deploying and managing camera traps in the field

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