Spatial and temporal partitioning of brush-tailed rock wallabies and a competitor species in Flinders-Goolman Conservation Estate, South East Queensland.

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List of Acronyms

BTRW	Brush-tailed Rock Wallaby
SEQ	South East Queensland
SW	Swamp Wallaby
FGCE	Flinders-Goolman Conservation Estate
FKC	Flinders Karawatha Corridor
RE	Regional Ecosystem
ICC	Ipswich City Council
FPCP	Flinders Peak Conservation Park
REDD	Regional Ecosystem Description Database
EPBC	Environment Protection and Biodiversity Conservation
IUCN	International Union for Conservation of Nature
GPS	Global Positioning System
WPSQ	Wildlife Preservation Society of Queensland

Abstract

The loss of terrestrial biodiversity on a global scale is primarily attributed to habitat loss and fragmentation. In Queensland, extensive ecosystem transformation as a result of land clearing impacts the 'Vulnerable' brush-tailed rock wallaby (*Petrogale penicillata*). This study assessed brush-tailed rock wallaby (BTRW) activity and interactions with a potential competitor species (e.g. swamp wallaby) by installing ten passive infrared cameras to monitor wallaby activity in Ipswich, Queensland. The images from the cameras were used to investigate activity patterns of the two species. A total of 34 BTRW events were recorded. Swamp wallaby events had a higher recording rate at 305 events recorded, which makes sense as the BTRW is 'Vulnerable' while swamp wallabies are not. Wallaby activity mainly occurred near the creek and on the rocky scree below the ledge. It was found that the BTRW were mainly diurnal, whereas swamp wallabies were vespertine. In contrast, predator activity was almost exclusively nocturnal. Scat analysis conducted on three scats showed that wallabies were not being predated on. The diurnal nature of BTRW activity is significant for future management of the site; for example, weed management activities should be undertaken in the afternoon so as not to disturb the BTRW, since they were primarily observed between dawn to midday. Future studies for this site may include a more comprehensive vegetation assessment combined with a dietary analysis of BTRW scats to explain why certain sites have higher rates of activity. This information could help to determine the population size of each wallaby species for future management options.

Key Words: Biodiversity loss, fauna monitoring, Flinders-Goolman Conservation Estate, inter-specific competition, camera traps.

1.0 Introduction

"Human-induced habitat loss and fragmentation are the largest factors contributing to the decline and loss of terrestrial biodiversity worldwide" (Eyre, 2002). Woodlands or forests have suffered substantial losses in Australia, around half of these ecosystems have been modified or removed to allow for agricultural development (Taylor, 2011). The clearing of vegetation leads to a reduction in habitat, which in turn results in decreased faunal population sizes. Smaller populations of fauna are more vulnerable to demographic and/or environmental stochasticity (Fahrig, 1997), which is a key threatening process for biodiversity loss. Habitat loss has been identified as the major driver for the decline of native wildlife (McAlpine, 2002). Urban expansion, nature-based tourism and invasive species are key drivers for increased habitat loss and impacts on native wildlife (McAlpine, 2002).

Urban expansion is a major driver for ecological change, with the ability to significantly alter natural landscapes (Bohnet, 2010). In South East Queensland (SEQ), the pressure on the area's biodiversity from urban spread will increase significantly with the predicted population rise of approximately 2 million people over the next 25 years (Queensland Government, 2017). The increase in population size has effects for nature-based tourism such as the increased demand for commercial and private recreational use of national parks, conservation reserves and fragile environments (Walsh, 1998).

Nature-based tourism is increasingly popular on a global scale, with activities such as hiking having negative impacts on the natural environment through soil erosion, compaction and changes to soil nutrient levels (Ballantyne, 2015). Habitat quality for native wildlife may degrade, and the range of suitable habitat may shrink, limiting species to smaller population sizes. These changes to soil condition and vegetation growth in habitats has the potential to create ideal colonisation opportunities for invasive plant species.

Invasive species (e.g. pest plants and animals or disease) are an anthropogenic addition to wildlife endangerment, affecting 82% of threatened species in Australia (Kearney, 2018). Creeping lantana (*Lantana montevidensis*) is one such species. Lantana has spread into National Parks and grazing land, competing with native flora. This competition negatively impacts ecosystem processes, which results in a reduction of biodiversity (O'Donnell, 2019). Increased rates of predation and competition from invasive species also heavily impact native wildlife in Australia (Hazlitt, 2006).

The target species for this project was the BTRW (*Petrogale penicillata*). BTRW are rocky habitat specialists and are heavily impacted from urban expansion, nature-based tourism and invasive species. Habitat specialists and rare species are particularly at risk of experiencing negative impacts from habitat loss (McAlpine, 2002). Existing in small isolated populations across SEQ, BTRW experience devastating stochastic events such as inbreeding depression resulting in a loss of genetic variation (Menkhorst, 2011). As such, BTRW have experienced drastic declines in abundance and distribution across SEQ (Hazlitt, 2006). In addition to these pressures, BTRW experience competition and predation from introduced predators such as the red fox (*Vulpes vulpes*) and wild dog (*Canis lupus familiaris*) (Hazlitt, 2006). The combination of habitat loss from urban expansion, environmental changes from nature-based tourism and predation from invasive species continues to threaten long-term persistence of this already declining species.

For comparison, a habitat generalist like the swamp wallaby (SW; *Wallabia bicolor*) are persisting at much higher rates expanding their distribution (Allen, 2016). This expansion has been attributed to the high dietary versatility of SW. Dietary and habitat generalists are better adapted to occupying peri-urban areas, providing an advantage over habitat specialists such as the BTRW (Allen, 2016). This allows SW to persist where BTRW cannot.

However, BTRW and SW are found to occasionally co-exist which may be indicative of resource partitioning on a spatial or temporal level to facilitate the observed co-existence (Yick, 2011), which was a key area of investigation for this project. Sympatric herbivore species have observed differences in habitat preferences due to differences in feeding strategies, allowing an exploitation of the environment in a unique way. This results in a reduction of interspecific competition on a broad scale. In the case of co-existence and therefore habitat overlap, spatial resources can be partitioned temporally at a finer scale (Davis *et.al*, 2017). Previously interspecific competition was thought to limit the use of spatial resources, however a fine scale temporal partitioning working where spatial exploitation overlaps may be minimising the negative effects of interspecific competition (Davis *et.al,* 2017).

Outside of a few small-scale studies, BTRW have limited baseline data available in SEQ. This study will focus on the spatial and temporal activity patterns of both BTRW and SW in the Flinders-Goolman Conservation Estate (FGCE) in Ipswich. The monitoring undertaken throughout this project will be valuable in assessing key potential drivers for the observed activity patterns of the BTRW.

Introduction influenced from project brief (Dyer, 2019).

2.0 Aim & Objectives

2.1 Aim of Project

The aim of this project was to 1) investigate the spatial and temporal partitioning between BTRW and SW, and 2) determine potential factors (such as predation, inter-specific competition, and habitat) that influenced the activity observed. The results from this project will fill a knowledge gap on BTRW activity in the SEQ BTRW population.

2.2 Objectives of Project

The objectives of this project were:

- ➔ To conduct a series of monitoring surveys using infrared cameras at a specified study site within the FGCE to monitor BTRW and SW activity.
- ➔ To assess the vegetation type and availability of the study site to explain wallaby activity.
- ➔ To identify the presence/absence of predators (specifically wild dogs) and identify the species using scat analysis techniques.
- ➔ To analyse the data to draw meaningful relationships between wallabies and the interactions with their environment.
- ➔ To provide information on BTRW activity in SEQ.

3.0 Methodology

3.1 Study Area

The Flinders Karawatha Corridor (FKC) is a large continuous stretch of open eucalypt forest located in SEQ, and is an important biodiversity corridor of local, state, and regional significance (Queensland Government, 2019). There are natural values attached to the site as the FKC is home to rare and threatened flora and fauna such as the powerful owl, BTRW, and swamp tea-tree. There are also a range of cultural heritage values associated with the corridor including Aboriginal and European historical sites and recreational opportunities for the nearby residential areas (Queensland Government, 2019). Within the FKC there are numerous protected areas (Figure 1) that represent a range of Regional Ecosystems (RE). One of these protected areas is the FGCE; an estate located in the Teviot Range and relevant to this project.

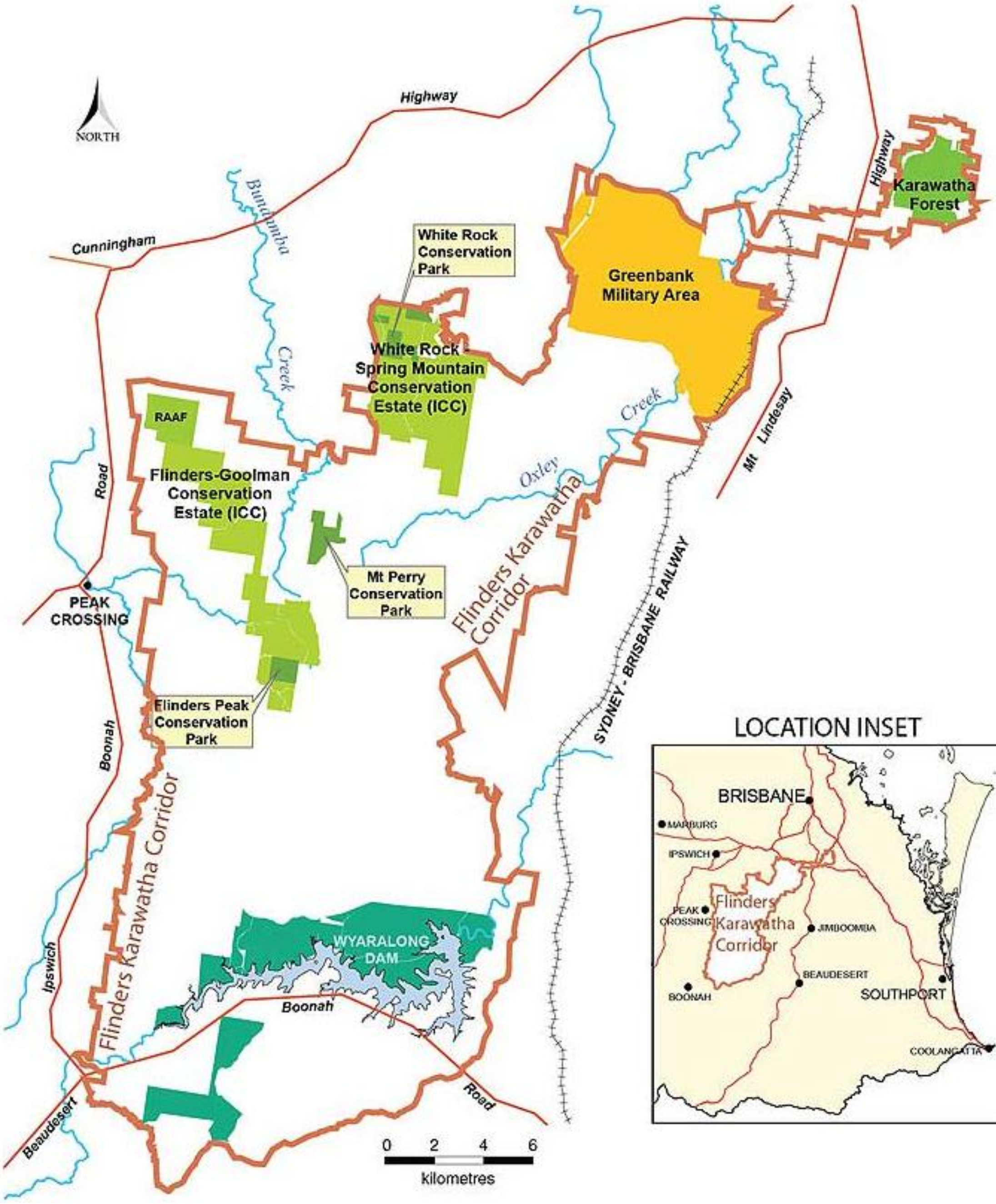

Figure 1: *Map of the Flinders Karawatha Corridor (FKC) as outlined in orange, conservation areas described by the green colour. Area of interest is the Flinders-Goolman Conservation Estate, specifically the Flinders Peak Conservation Park in dark green. Inset shows the location of the FKC in the greater Brisbane context. Source: Queensland Government 2019.*

"The Teviot Range extends from south-eastern Ipswich to northern parts of Scenic Rim and south-west Logan" (Ipswich City Council, 2019). The area of interest is the 2,200 hectare FGCE in Ipswich, SEQ (Figure 1) in the Ipswich City Council (ICC) local government authority. Within the FGCE is the state-owned protected area Flinders Peak Conservation Park (FPCP), which spans approximately 106 hectares (Figure 1). The primary purpose of the FPCP is the protection of the BTRW habitat (Ipswich City Council, 2019). FGCE also has a sacred history with Traditional Owners. It is a culturally significant site through ceremonial activities such as fighting grounds, bora rings and women's business (Ipswich City Council, 2018).

The broad vegetation types of FGCE are eucalypt woodlands to open forests and heaths. Furthermore, two different REs have been identified as present by the ICC and are classified in the Regional Ecosystem Description Database (REDD) by the Queensland Government (Appendix 1). The two REs present are 12.8.9 and 12.8.24 (listed as Endangered), both open forest on igneous rock (Appendix 1). This area supports 149 species including 97 birds, 21 insects, 13 mammals, 12 reptiles, 4 amphibians and 1 ray-finned fish (Appendix 3).

3.2 Study Species

Brush-tailed rock wallaby:

The BTRW (Figure 2) is a "medium-sized marsupial macropod that was formerly widely distributed in south-eastern Australia, from south-eastern Queensland through eastern and central New South Wales and the Australian Capital Territory to western Victoria" (Menkhorst, 2011). They are listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) but have different conservation statuses under different state jurisdictions. New South Wales lists BTRW as more critically 'Endangered'. The population size for FGCE is unknown, but the overall trend for QLD's population is a "widespread decline in range and abundance, with a major range contraction and local extinctions in many areas" (Menkhorst, 2011). The threats influencing this decline include predation, habitat degradation, habitat fragmentation, and stochastic events associated with small population sizes (Carter, 2003). The home range of BTRW is relatively small, estimated at around 3 ha (Laws, 2003). BTRW are both nocturnal and diurnal, primarily foraging at night. A study conducted in the Snowy River National Park (VIC) by L. van Eeden (2011) showed that the diet of BTRW consists of forbs (i.e. herbaceous flowering plants other than a grass), monocots, and shrubs, with a clear selection preference for forbs at each of the three study sites. The broad vegetation assessment conducted during this project was classified into these groups with an abundance of shrubs and monocots in the study area. The rocky habitat requirements coupled with the need to forage limit the distribution of BTRW to an uneven and isolated distribution. The reproductive cycle of BTRW is relatively short and a 64% mortality rate of young inhibits the ability of the BTRW to bounce back from decline or genetic bottlenecks. As this population is assumed to be small and isolated, the observed mortality rate is suspected to stem from increased rates of inbreeding (Menkhorst, 2011).

Figure 2: *Brush-tailed rock wallaby (Petrogale penicillata) in Flinders-Goolman Conservation Estate. Image enlarged from original size to highlight morphological features. Photo courtesy of Timothy Shields (Ipswich City Council 2018).*

Swamp Wallaby:

The SW is a small marsupial macropod (Figure 3) that "maintains a broad distribution along the eastern coast of Australia and records have indicated that its range may be expanding" (Allen, 2016). SW are listed as 'Least Concern' under the International Union for Conservation of Nature (IUCN) Red List and are not listed under the EPBC Act 1999. Once again, the population size of SW in FGCE is unknown, but due to the higher overall population numbers, it can be assumed that the SW population is larger than the BTRW population. There are no major threats to SW, hence its low conservation status, but some minor threats include predation and habitat degradation. Habitat fragmentation is not an issue for the SW as their habitat requirements are more generalised and their home range is slightly larger at 16 ha (Allen, 2016). SW are primarily diurnal but have been observed to exhibit occasional nocturnal foraging behaviour, not unlike that of the BTRW (Allen, 2016). A dietary study analysing stomach contents of roadkill SW showed that a wide range of plant categories were consumed. Their diet consists of shrubs, forbs, grasses, fern, fungi, sedges, and vines (Allen, 2016), with grasses followed by shrubs the two most dominant plant categories (Osawa, 1990). The different foraging habits and dietary preferences between SW and BTRW suggests a spatial or temporal differentiation to avoid competition.

Figure 3: *Swamp wallaby (Wallabia bicolor) image enlarged from original size to highlight morphological features. Source: Moonlit Sanctuary 2019.*

Methodology influenced from project brief (Dyer, 2019).

3.3 Monitoring of Study Species

The occurrence and activity of BTRW and SW was recorded using infrared digital cameras. Google Earth was used to pin ten potential camera sites near ICC's site RW08 in FGCE based on varying vegetation types, terrain, and landscape features. The measurement tool in Google Earth was used to measure approximately 50 m between each camera. A GARMIN GPSMAP64s Global Positioning System (GPS) was used once in the field to navigate to the pre-determined camera positions, and suitable install locations and orientations were chosen based on the view of features such as wildlife trails. The resulting camera deployment layout was mapped on QGIS using the GPS coordinates (decimal degrees) (Figure 4). This placement of cameras meant that individuals had the potential to be captured on adjacent cameras. The area covered by these cameras (including a buffer zone for the camera range) is estimated to be 2.7 ha, similar to BTRW home range. The implication of the cameras being in close proximity is that observations and camera sites were not truly independent. However, since the aim of the project was to provide spatial and temporal visualisations, the lack of independence is not relevant.

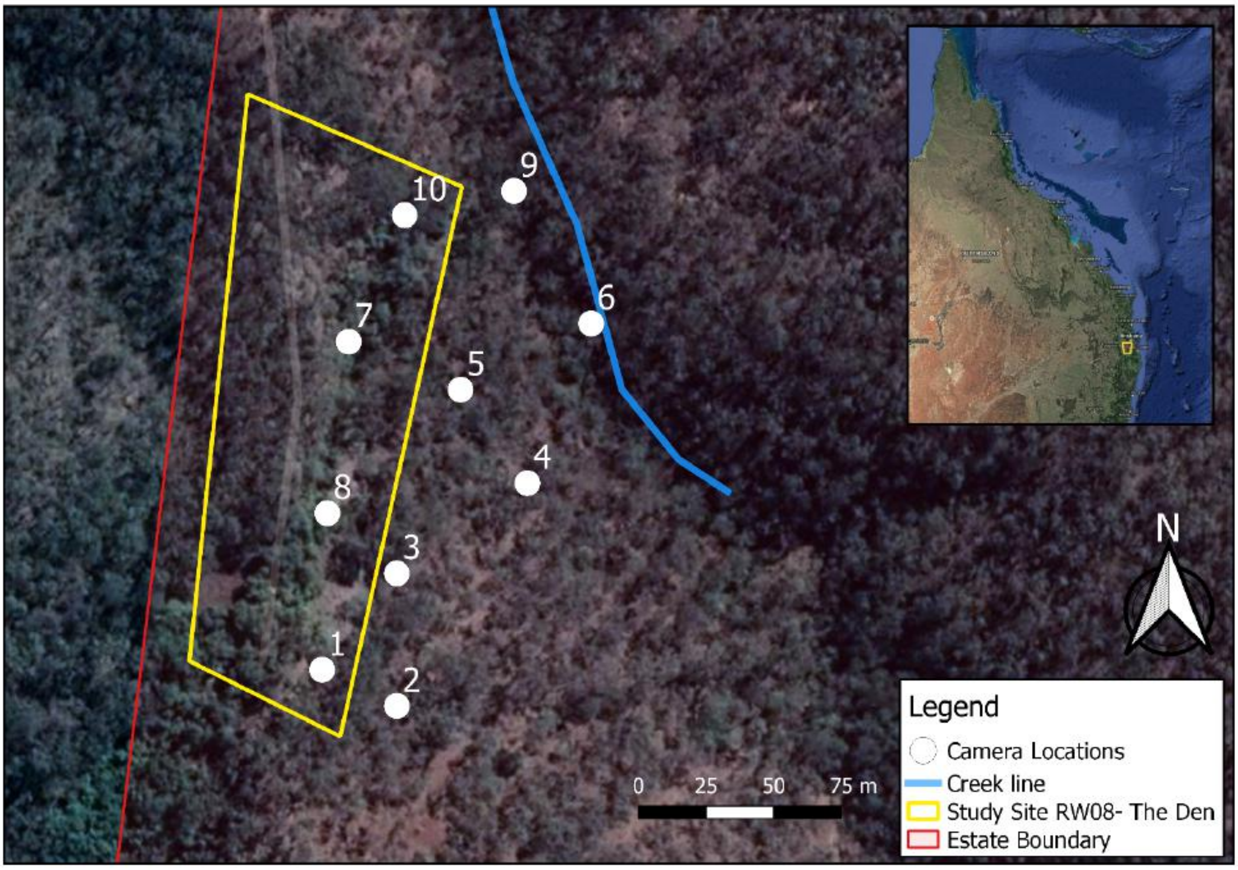

Figure 4: *Wallaby monitoring camera locations in Flinders-Goolman Conservation Estate. The Ipswich City Council site RW08 is outlined in yellow. Inset shows the location of the study site within the context of South East Queensland.*

Cameras were installed on the 12th August 2019 and remained in the field until the 22nd October 2019. Fortnightly checks for batteries and SD card swaps were made five times throughout the deployment. This method was chosen as it has been acknowledged as an effective time frame for camera deployment (Meek, 2012). All cameras were active 24 hours a day, automatically triggered by movements of infrared sources (i.e. heat and motion) detected by a sensor, with the cameras set to take a series of three pictures one second apart after being triggered. Images were stored on either an 8-GB Delkin Devices SD 163X or 16-GB SanDisk Ultra Compact Flash Card. Details of the cameras used are described in Table 1.

Table 1: *Camera trap details (Site, Camera make, Camera model, Orientation, Site description and elevation) at time of deployment at RW08 in Flinders-Goolman Conservation Estate. All cameras were infrared flash type.*

Site	Camera make	Camera model	Orientation	Site description	Elevation (m)
1	Reconyx	HC500 HyperFire™	SE	High upon scree, facing eucalypt woodland slope	271
2	ScoutGuard	SG560K-18M HD	NE	High upon slope, open eucalypt, grassy	262
3	Reconyx	HC500 HyperFire™	S	Eucalypt woodland, open understorey	245
4	ScoutGuard	SG560K-18M HD	NE	Eucalypt woodland, down slope, open grassy	212
5	ScoutGuard	SG562C	S	Eucalypt woodland, east of dry vine, grassy ground cover	204
6	Reconyx	HC500 HyperFire™	S, SW	Lantana treatment site, dry creek	180
7	ScoutGuard	SG560K-18M HD	SW	Facing den and ledge (rock-climbing nodes on site)	239
8	Reconyx	HC500 HyperFire™	NW	Scree beneath cliff, flight path	247
9	ScoutGuard	SG562C	S	8m from drainage feature, edge of dry rainforest, just out of scree	180
10	Reconyx	HC500 HyperFire™	S	Scree: edge (West), fig tree, vines, edge of *A. fimbriata*	196

The orientation of five of the ten cameras was adjusted (Table 2) based on reviewing images and finding low visibility of animals (e.g. a wallaby tail was caught but the wallaby was always off-camera). The adjustments made aimed to increase the visibility of the animal for identification purposes and to gain a more accurate picture of wallaby activity. The final orientation of all cameras can be seen in

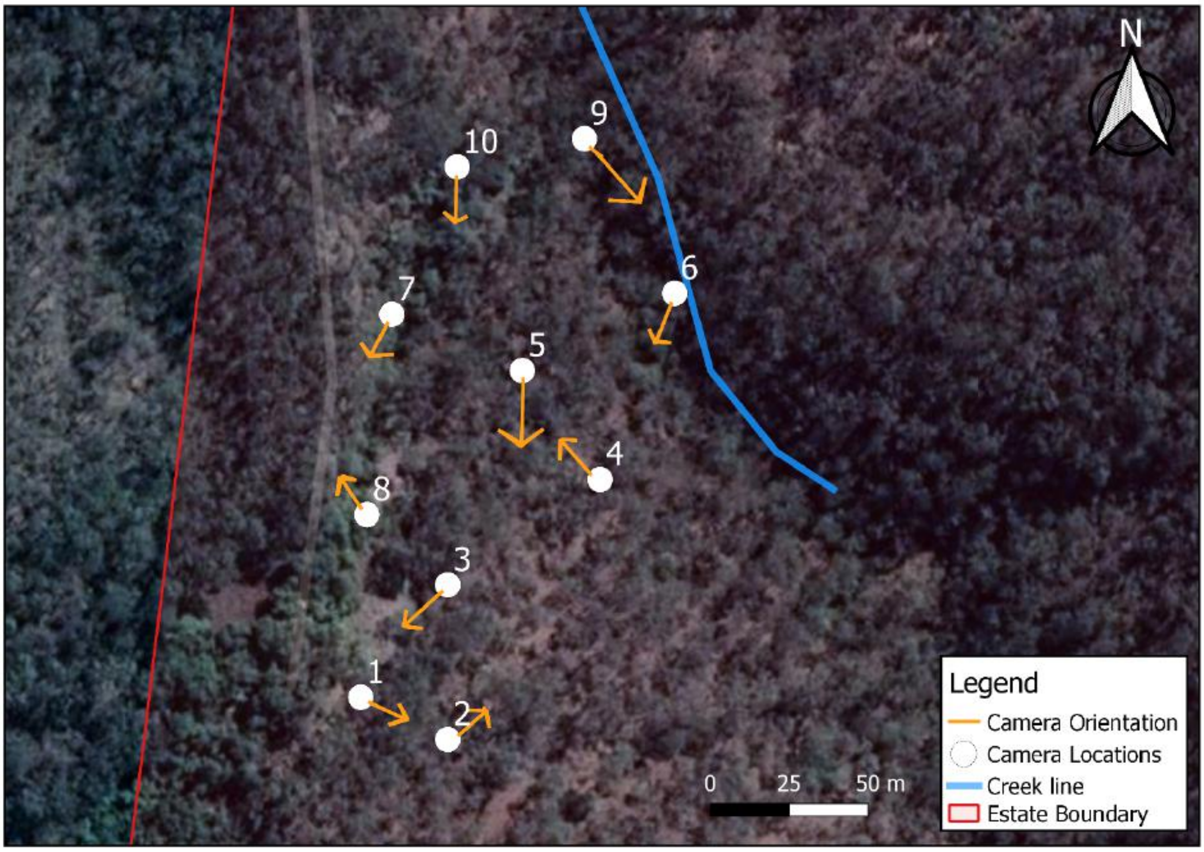

Figure *5*.

Table 2: *Camera orientation changes in Flinders-Goolman Conservation Estate throughout the monitoring period.*

Camera Number	Date Changed	Previous Orientation	New Orientation
1	09/09/2019	South-East	East, South-East
3	09/09/2019	South	South-West
6	09/09/2019	South, South-West	South-West
9	09/09/2019	South	South-East
4	23/09/2019	North-East	North-West

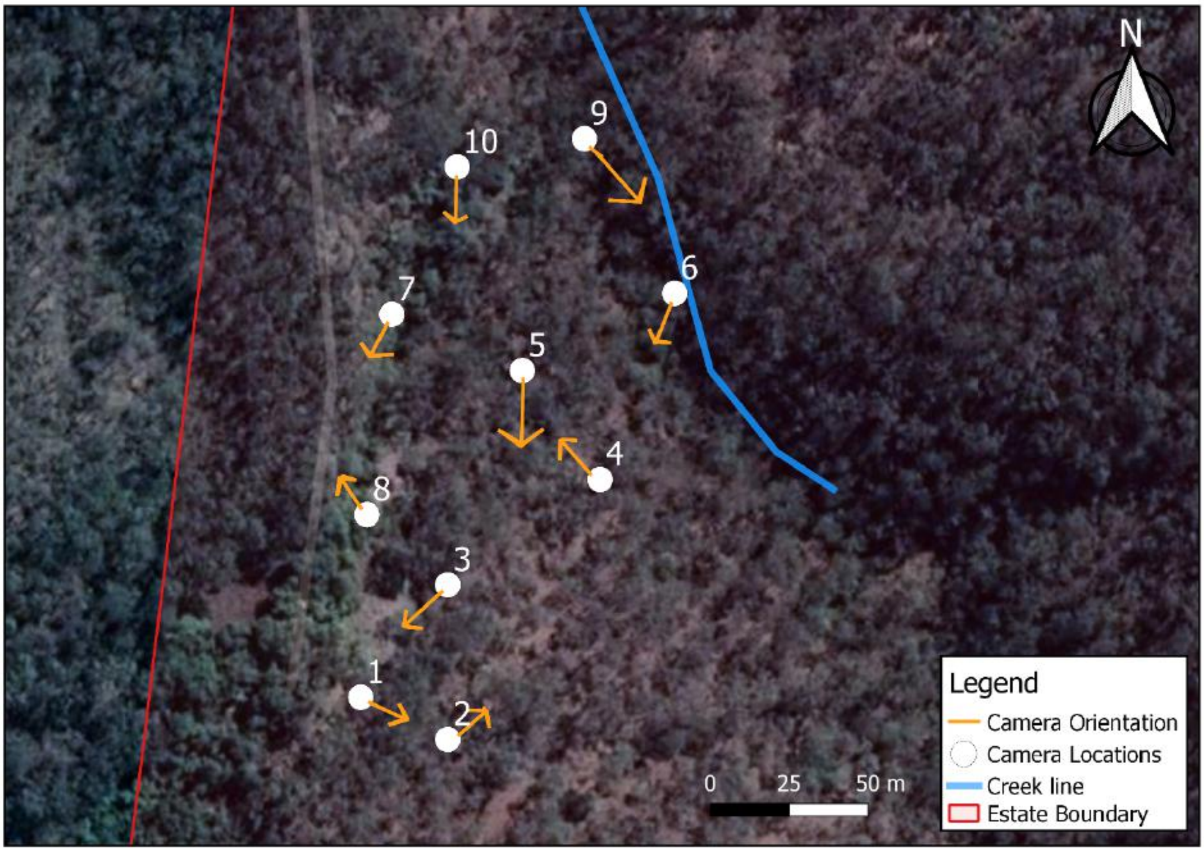

Figure 5: *Final camera orientations in Flinders-Goolman Conservation Estate. Camera orientation is indicated by the orange arrow.*

A vegetation assessment was carried out on the final trip to the field, where supervisor Matt Cecil identified dominant canopy and foraging species to the best of his ability. Photos and leaf samples of unknown plant species were taken back to the office for further identification. The study site was classified into four broad vegetation categories according to these dominant species and the RE description.

Three predator scats were opportunistically collected during trips to the field and the GPS coordinates of each scat was recorded while in the field (Figure 6). Scat 1 was located outside of FGCE on a separate field trip to assist Quoll Seekers Network in collecting their cameras but was included in analysis as predators can move greater distances than wallabies. The scats were handled safely and appropriately stored in paper bags and then sealed in a zip-lock bag for ease of postage. The scats were analysed by Barbara Triggs, a scat analysis specialist and independent researcher in Victoria, Australia.

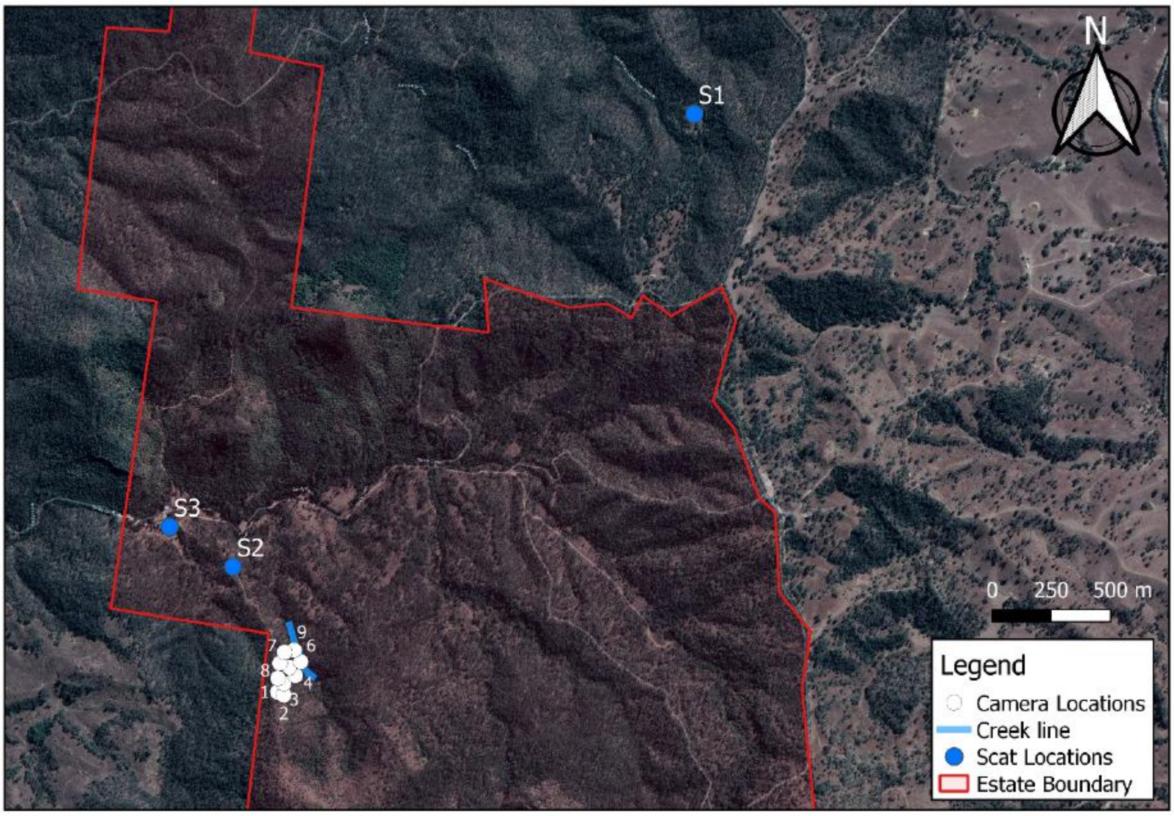

Figure 6: *Predator scat locations with respect to the monitoring cameras in Flinders-Goolman Conservation Estate, Ipswich.*

3.4 Data Coding & Analysis

Similar to Meek's temporal study on small mammals (2012), we were unable to identify unique individuals from the images. Since the aim of the project was to investigate spatial patterns rather than abundance, the term 'event' was adopted to define a series of images taken by a camera trap. A gap in visitation of more than five minutes was defined as a new event. This number was assigned as there were many series of images where a SW forages in front of the camera for roughly five minutes and can be confidently identified as the same individual.

Microsoft Excel was used to sort the data by cameras then conditional statements were used to classify observations more than five minutes apart as individual 'events.' The events were assigned the number "1", where other observations within five minutes of another observation were assigned a "0". The occasional manual entry was needed for the sighting of a unique species less than five minutes from the species before because the conditional statement did not recognise unique species observations, just the time difference in visitation. Another output of camera traps is photographic rates, which should be interpreted as an index of activity rather than an index of abundance (Sollmann, 2018). From this, data can be analysed using linear mixed models, however this requires spatial independence (Sollmann, 2018). The camera trap design lacks spatial independence; therefore, we analysed the data spatially and temporally based on activity patterns and counts of events rather than counts of individuals. Proportional analysis was conducted on the proportion of counts of events per species across each of the ten different cameras.

Population sizes and abundance of wallabies was not measured therefore if two or more wallabies of the same species were in a single image it was treated as the same event. If two individuals from different species were observed in the same image, then a copy of the data was made to record one event per species (i.e. one identical observation per species).

Camera trap images can be difficult to differentiate morphologically similar wallaby species (Meek, 2012). Species identification was especially difficult between SW and BTRW as they have similar colourations and physiological features. This became particularly difficult with the images taken at night, as the camera flash altered the success rate of differentiating SW and BTRW based on colouration as observed in the images taken during the day. In cases where the identity of the species was unclear the observation was classified as "Unknown". The occasional image was completely unidentifiable to a class level; these observations were classified as "Unidentified". Both classifications were ignored for data analysis to avoid a misrepresentation of BTRW and SW activity. Identification of species was conducted using multiple field guides to Australian mammals (Menkhorst, 2001 & Van Dyck, 2008) to cross-reference morphological features observed in camera trap images with existing observations.

3.4.1 Mapping & Graphing

Data was categorised by camera number and the time of observation. Proportional analysis was run to understand the percentage of the focal species (SW, BTRW and wild dogs) that fell into each of these two categories (i.e. spatial and temporal categories). Data analysis was conducted for the two groups of spatial and temporal data through Excel and QGIS. Temporal data was categorised into two different formats for analysis. The first was by standardising night and day times into two 12 h blocks. "Day" was defined as 5am to 5pm and "night" was defined as 5pm to 5am. These were assigned according to the average sunrise and sunset times at the commencement and completion of the project. The second categorisation of temporal data was by dividing a standard 24 h day into six times four hour blocks where 12am until 4am was defined as "early morning", 4am to 8am was defined as "dawn", 8am to 12pm was defined as "morning", 12pm to 4pm was considered "afternoon", 4pm to 8pm was considered "dusk" and 8pm-12am was considered "night". Spatial data was categorised according to the camera trap number.

4.0 Results

Data was analysed from a total of 72 camera trap "days", which is equivalent to ~17 280 h of field observations. Over the survey period, a total of 34 BTRW, 305 SW and 14 predator events were recorded, where a single event had 1-60 images taken. Measuring abundance was not an objective of this project and so these images were assumed to be the same individual. In total, 14 unique species were identified throughout the survey period (Figure 7). Three predator scats were collected and analysed. Invasive plants such as creeping lantana (*Lantana montevidensis*) were present throughout the study area and dominant canopy and foraging species were listed (Table 3) and mapped (Figure 8).

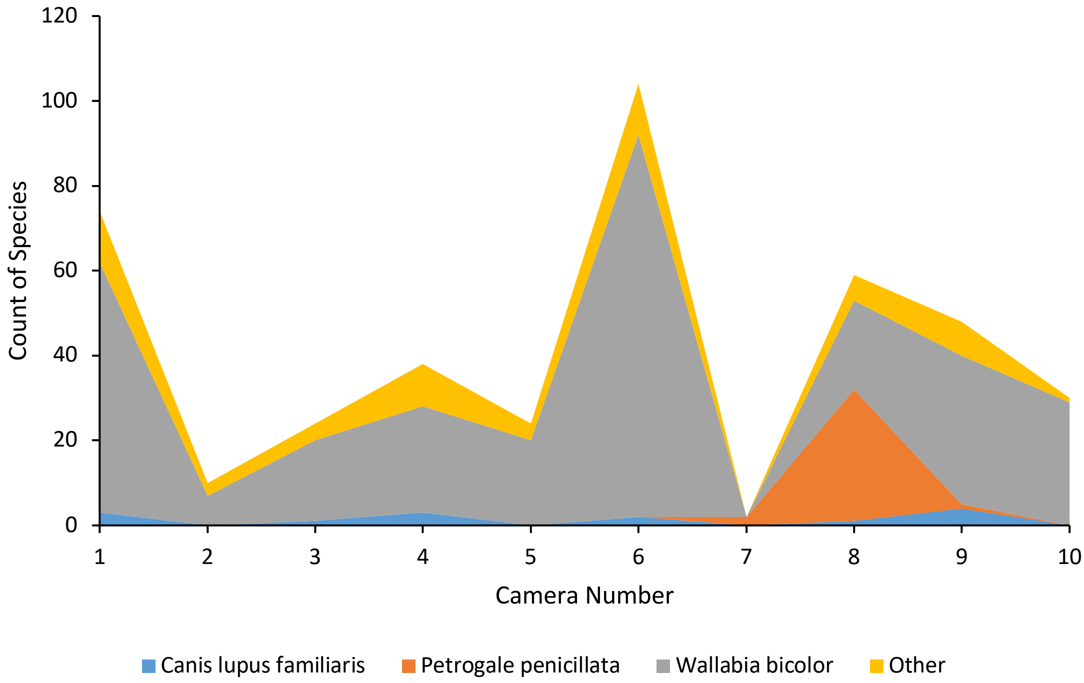

Figure 7: *Stacked area chart showing the number of focal species observed at each camera site. "Other" includes red-necked wallabies, whiptail wallabies, foxes, echidnas, lace monitors, sand goannas, pigeons, kookaburras, magpies, bandicoots and currawongs.*

Table 3: *List of dominant canopy and foraging flora species present in each broad vegetation classification.*

BROAD VEGETATION CLASSIFICATION			
Acacia Woodland	**Lophostemon Open Forest**	**Dry Rainforest Heath**	**Open Eucalypt Forest**
Acacia fimbriata *Eucalyptus crebra* *Corymbia citriodora* *Psydrax odorata* *Lantana montevidensis* *Alyxia ruscifolia*	*Lantana montevidensis* *Lantana camara* *Dianella caerulea* *Lophostemon confertus* *Psydrax odorata* *Alyxia ruscifolia*	*Alphitonia excelsa* *Acacia fimbriata* *Psydrax odorata* *Cymbopogon refractus* *Ficus rubiginosa* *Alyxia ruscifolia* *Mallotus philippensis* *Austrosteenisia blackii*	*Lomandra confertifolia* *Smilax australis* *Eucalyptus crebra* *Lomandra confertifolia subsp. pallida* *Corymbia citriodora* *Lantana montevidensis* *Psydrax odorata* *Maclura cochinchinensis*

Camera trap placements were biased towards open eucalypt woodland due to the larger coverage area, with four out of ten cameras situated within this vegetation category (Figure 8). No cameras were placed in the acacia woodland due to the relatively small distance chosen between cameras (50 m). Three cameras were located along the scree (dry rainforest heath), with Cameras 1 and 10 bordering the neighbouring vegetation type (Figure 8). While the map designates borders for vegetation categories, there was often overlap between plant species encroaching on the neighbouring category (Table 3), rather than a drastic change from one composition to the next.

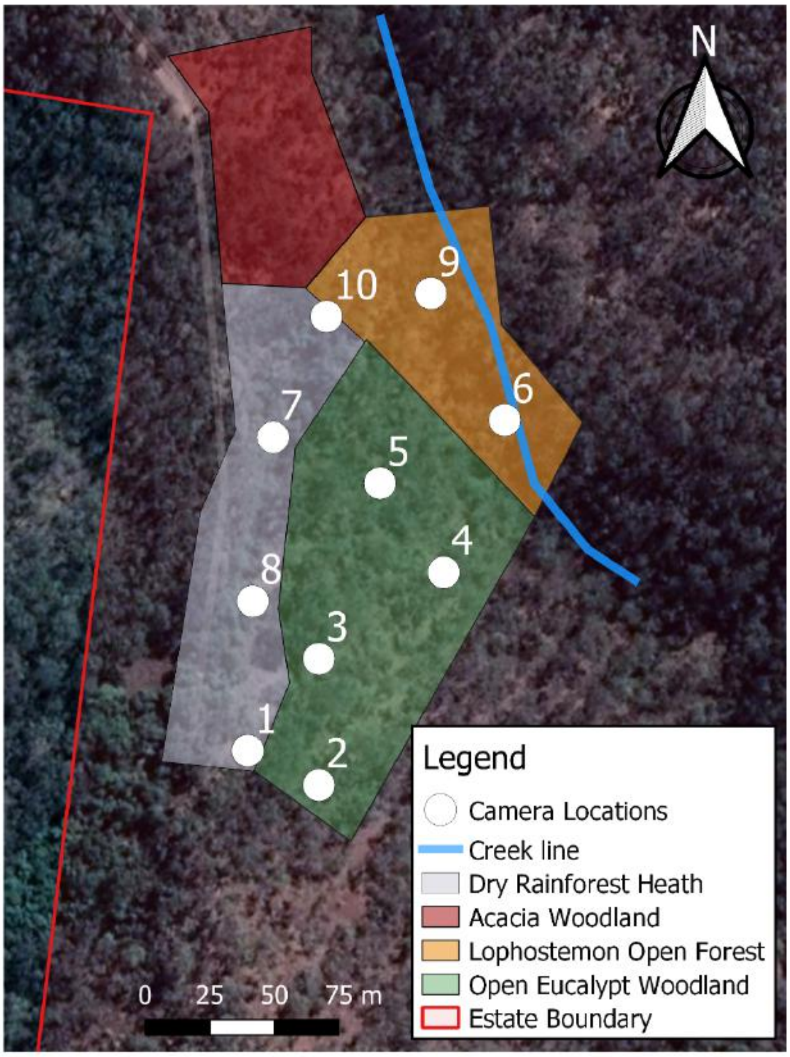

Figure 8: *Broad vegetation classifications based on the dominant canopy and foraging species present in the study area showing the distribution of camera locations and their respective vegetation type.*

4.1 Spatial Patterns

The spatial distribution of BTRW and SW activity varied greatly between sites, with cameras 1, 6 and 8 being "hotspots" for wallaby activity (Figure 9a, c). SW activity was primarily captured on Camera 6 near the creek, situated in lophostemon open forest and Camera 1, bordering the scree and open eucalypt woodland (Figure 9a). Wild dog activity contrasted to that of the SW with Cameras 4 and 9 being heavily visited, and an overlap of visitation at Camera 1 (Figure 9a). Once again, activity between these two occurs in lophostemon open forest along the creek line and the scree slope, with Camera 4 being an outlier situated in open eucalypt woodland and also displaying higher visitation rates by the wild dogs. BTRW activity is highly concentrated along the scree slope, specifically Camera 8, with light activity being recorded at the den site (Camera 7), and a one-off recording event at Camera 9 (Figure 9c). BTRW activity primarily occurred in the dry rainforest heath of the scree slope, with a single visit to the lophostemon open forest near the creek line.

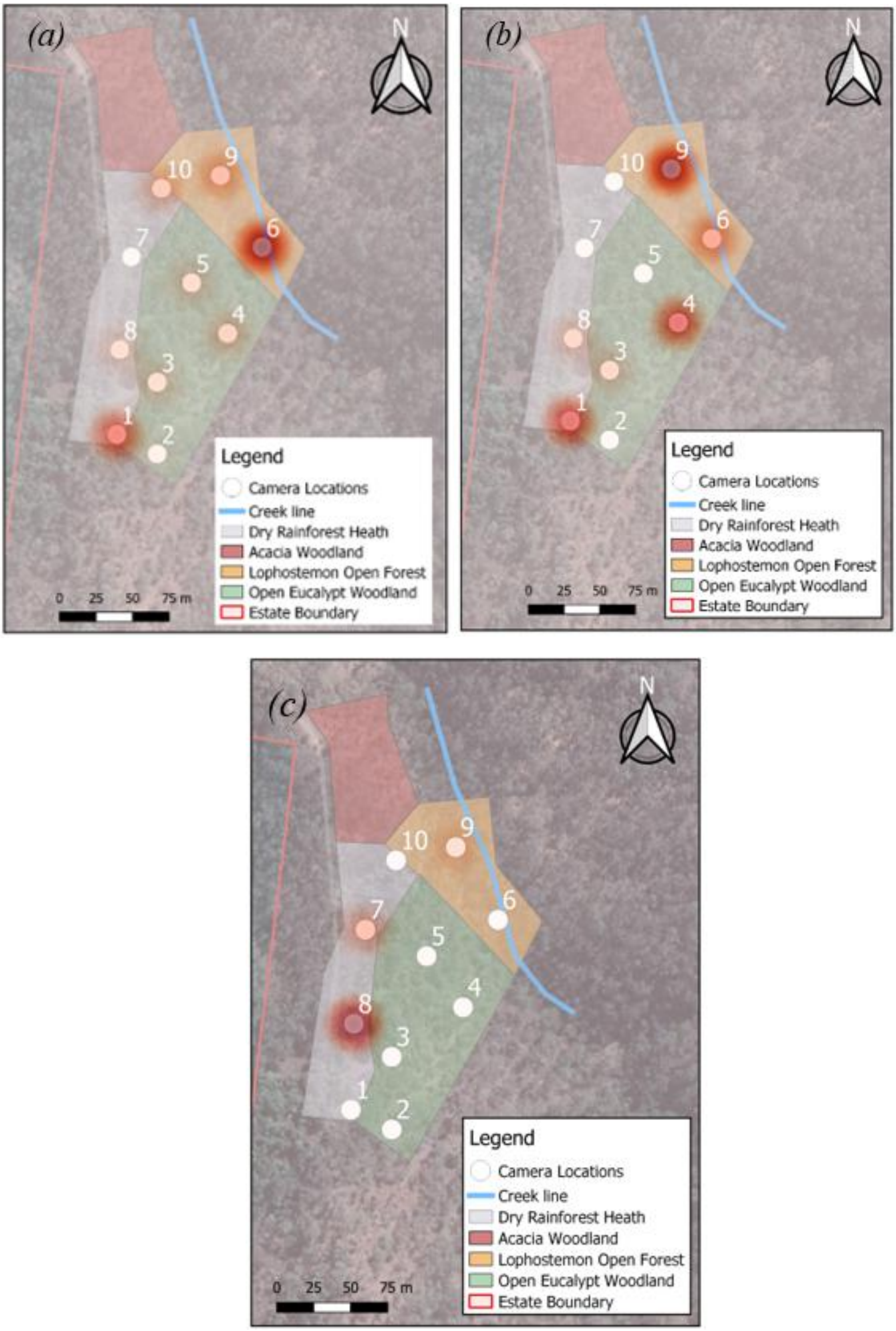

Figure 9: *Heatmaps showing the distribution of animal activity across ten different camera sites in Flinders-Goolman Conservation Estate, where (a) is swamp wallaby activity, (b) is wild dog activity, and (c) is brush-tailed rock wallaby activity.*

In classifying the camera trap images, an anomaly was found where the spatial separation of wallabies was not observed, and the BTRW (circled) and SW were captured in the same image (Figure 10). This was only observed for a series of six pictures in which the BTRW hopped off camera to the left and was no longer in the camera's field of view. This image displayed not only a spatial overlap but also a temporal overlap in activity patterns.

Figure 10: *Camera trap image of swamp wallaby (foreground) and rock wallaby (background) active at the same time at the same location. Image was taken on Camera 8 at the beginning of the monitoring period.*

While conducting the vegetation assessment, a significantly higher proportion of plants with evidence of browsing pressure was observed near Camera 8. There was evidence of browsing pressure on a series of small woody shrubs that were unidentifiable (Figure 11). The browsing pressure of these plants was noted because of the high density of the BTRW activity at Camera 8.

Figure 11: *Evidence of browsing pressure on small woody shrub on the scree slope. Image taken on 22nd October 2019, near Camera 8.*

4.2 Temporal Patterns

BTRW activity was mainly diurnal (Figure 12) with the peak hours of activity occurring between dawn (sunrise) and morning (Figure 13). Very little activity was seen from the BTRW in the darker hours (Figure 14). SW activity was higher at night, but a high percentage was during the day (Figure 12), with peak activity occurring across the early hours of the morning, dawn (sunrise) and dusk (sunset) (Figure 14). SW activity patterns had a much more even distribution across the daily cycle than BTRW activity patterns (Figure 13). In contrast, wild dogs were almost completely nocturnal (Figure 12), almost exclusively being captured by the camera during the hours of 12am to 4am, with minimal activity being recorded at dawn (Figure 13**Figure** ***13***).

Three cameras had high capture rates for the three focal species; Camera 1 primarily captured night activity, whereas Cameras 6 and 8 were biased towards capturing wallaby activity during the day (Figure 12). These distributions observed were attributed to the types of species captured on the cameras and their respective activity patterns. For example, Camera 8 captured a high density of BTRW activity (Figure 9) and with their diurnal behaviour it is expected that the camera will have a higher daytime proportion than night.

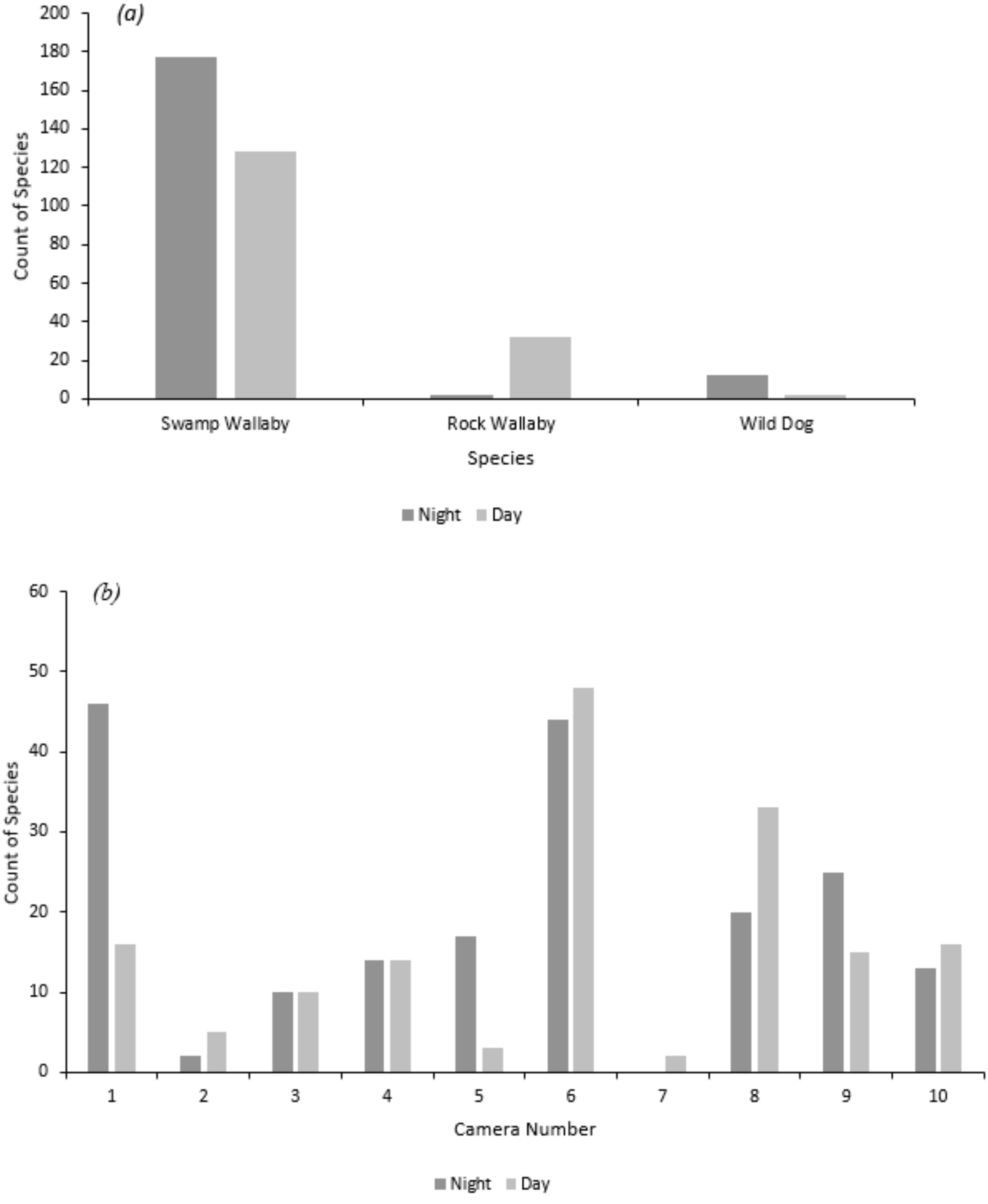

Figure 12: *Proportion of day and night activity based on the number of activity events (n=353) recorded during a 24 h period at the ten camera locations in South East Queensland presented by (a) species and (b) species combined across sites. "Night" is considered as the hours of 5pm to 5am, and "Day" is considered 5am to 5pm.*

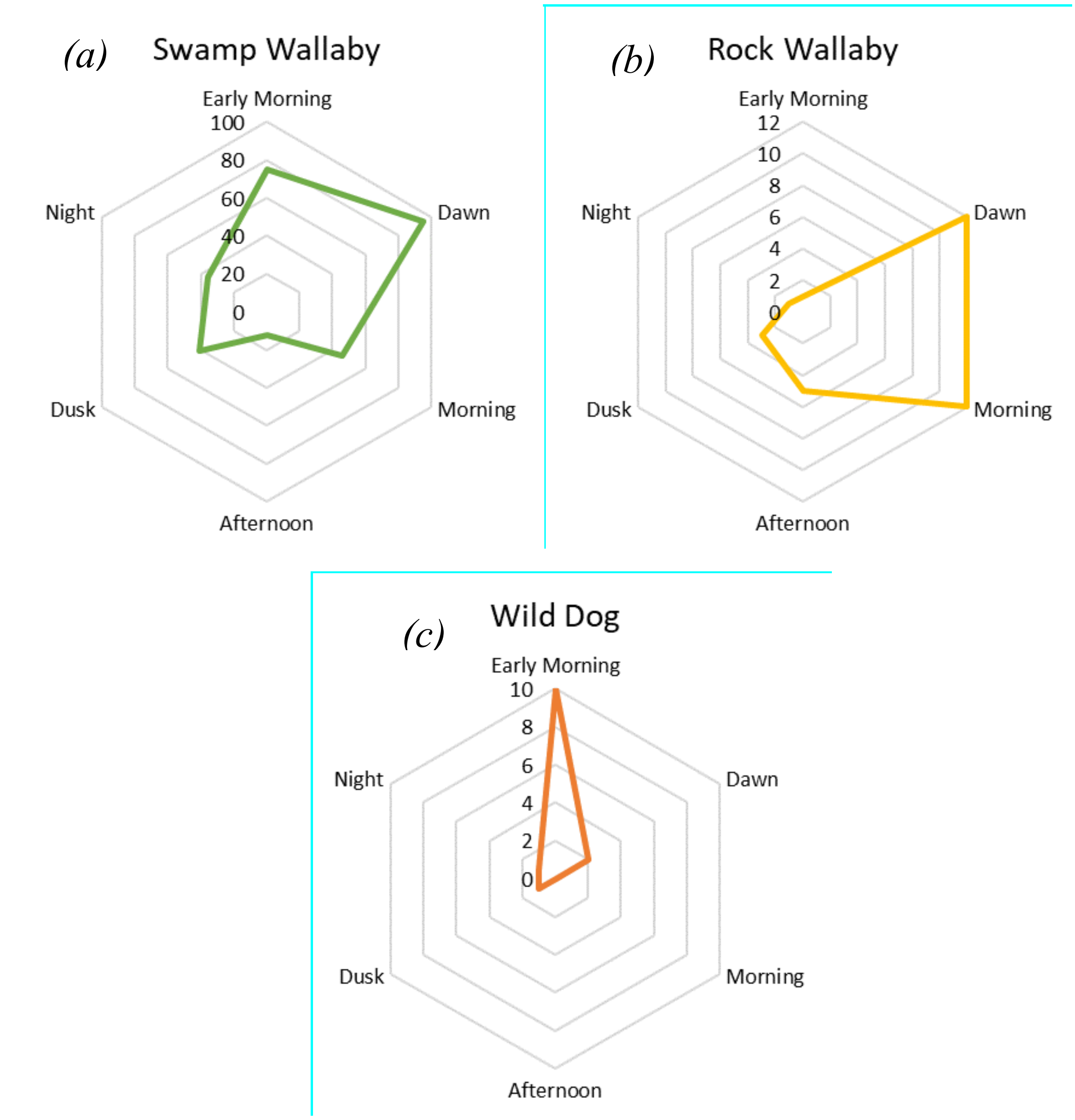

Figure 13: *Activity patterns over 24 h of (a) swamp wallabies, (b) rock wallabies and (c) wild dogs using camera traps at ten sites in South East Queensland. Standard 24 h day split into six times four-hour blocks, where early morning is 12am until 4am, dawn is 4am to 8am, morning is 8am to 12pm, afternoon is 12pm to 4pm, dusk is 4pm to 8pm, and night is 8pm to 12am.*

Figure 14: *Camera trap images showing (a) a swamp wallaby active during "early morning" and (b) a rock wallaby active during "morning". Both images are from Camera 8.*

4.3 Scat Analysis

Scat analysis was conducted externally to this project. The samples were analysed by Barbara Triggs, and results were emailed through in a simple Excel spreadsheet format, rearranged for ease of display (Table 4). The predator scats identified primarily belonged to wild dogs and foxes which were recorded in FGCE during the study (Figure 15).

Table 4: *Scat analysis results (scat number, type of scat, mammal present in scat).*

Scat Number	Scat Identification	Mammal Identification
1	Dog	*Canis lupus familiaris*
2	Fox	*Isodoon macrourus*
3	Fox	*Macropus sp.*

Figure 15: *Camera trap images of (a) a wild dog (Canis lupus familiaris) and (b) a red fox (Vulpes vulpes). Both images have been cropped and enlarged from the original to highlight the morphological features of the species. Both images were captured on the 19th October, with image (a) being captured on Camera 9 and image (b) being captured on Camera 8.*

5.0 Discussion

The heatmaps provide a starting point for determining what potential drivers may be behind the high levels of activity observed on specific cameras. These drivers are likely to vary between sites and species and may combine to form a complex array of behavioural patterns. The activity patterns of BTRW and SW are of particular interest due to the specialist nature of one and the generalist nature of the other. BTRW were highly concentrated on the rocky scree below the den site, with a once-off visitation recorded at the creek line. This kind of behaviour is supported by the literature and the BTRW tendency towards rocky habitats (Menkhorst, 2011). SW activity patterns were in accordance with the literature; being a generalist species they were observed across almost all of the camera traps, with foraging occurring mainly at night (Allen, 2016).

The image where BTRW and SW were captured together suggests the occasional overlap in activity patterns, which may lead to increased competition and an encroachment on the BTRW habitat by the SW (Allen, 2016). Being a generalist species, the SW can successfully inhabit rocky areas as well as the other vegetation areas, whereas BTRW are confined to these rocky areas alone. However, a BTRW was observed down near the creek line on Camera 9, which begs the question why. It should be noted that the creek was mostly dry for the duration of the study, with one small puddle observed on the final field visit. The implications of this overlap of SW on the scree may be causing the BTRW to expand their range slightly in search of food. Another potential driver for this anomaly may be the occurrence of a fox up on the scree the same week as the BTRW was at Camera 9. Perhaps there is a combination of predator and inter-specific competition avoidance on the part of the BTRW that drove them to expand their range. The browsing pressure on shrubs at Camera 8 may have also been evidence of SW consuming the food resource that BTRW require, and so it may have been a lack of food driving the BTRW to Camera 9.

Wild dogs were active across the same sites as SW, but only overlapped with BTRW on Camera 8 and 9. Where the BTRW, wild dogs and SW were found to coexist, a temporal differentiation was observed where BTRW were active at times opposite to the wild dogs and SW, which may be indicative of predator avoidance on behalf of the BTRW. The genetic isolation BTRW populations face make them particularly vulnerable to the effects of introduced predators (Hazlitt, 2006), and so predator avoidance may be a key driver explaining the observed temporal partitioning exhibited by the BTRW and wild dogs. The scat results show that BTRW and SW are not being eaten but this does not mean that their presence as a potential predator drives the BTRW to exhibit different behaviour to what it might in the absence of predators. The observed spatial patterns may be driven by browsing competition whereas predator avoidance occurs on the temporal level.

Due to limited time and resources, the vegetation assessment was quite rough and broad and aimed to potentially explain the spatial distribution of animal activity. Camera placement was biased towards the open eucalypt forest, however very little activity occurred on these cameras. The low density of animal activity may be explained by the open nature of the vegetation; there was an abundance of wildlife trails and so it would be expected that activity would be high. This was not the case, with wallabies moving through quite fast rather than stopping and foraging (like in Camera 6). There is no refuge in the open woodland, and while there is an abundance of movement of species, there is a lack of 'activity'. Creeping lantana was also very dominant throughout the site, especially in the open eucalypt woodland, so the normal browsing habits of SW and BTRW may be impacted. Both wallaby species' diets include grasses, of which may be outcompeted by the lantana and so secondary food sources such as the woody shrubs become the new driver for foraging behaviour. For future studies on this BTRW population a more comprehensive vegetation assessment could be conducted to determine the actual composition of the site, and with this information the browsing habits of the BTRW may be further understood. For example, a dietary analysis could be conducted on BTRW and SW scats and could be compared to investigate the level of competition between the two species for food resources.

Based on the temporal data for BTRW activity patterns, a recommendation for future management of the site would be to avoid conducting activities before 12pm, as that is when the BTRW are most active. For example, weeding activities to help promote native forage species should be conducted in the afternoon so as not to impact the BTRW activity cycles. If the more in-depth vegetation assessment was completed, then the environment the BTRW were observed in could be better understood; are foraging species dominant, or is it rocky cover that they tend towards?

While it was not an aim of the study, a very rough estimation of population numbers was conducted using assumptions and powers of deduction. For the BTRW population, there appears to be only one individual; the timestamps make a plausible case for one individual, however there were no other identifiable features of the wallaby that confirmed there was one and not two individuals. For the SW, there were at least five individuals, with this deduction being based off both timestamps and identifiable features. For example, there were two different mother and joey pairs, with one confirmed male. There may be another two or three individuals but there is no way to be scientifically certain.

6.0 Conclusion

The activity patterns of BTRW and SW have been found to differ in time and space in FGCE. The drivers of this is most likely a combination of both habitat type (vegetation composition) and predation, however further research is needed to investigate this. This project aimed to contribute information to the knowledge pool of BTRW and has not only achieved this but also provided many questions for future studies to investigate. In conducting any future study, a potential addition may be to set up cameras on the other side of the creek. In many of the photos, wallabies were seen travelling towards the next hill after the creek, but there is no current explanation for why that may be. Setting up a mirror project for the other hill may help explain the movement patterns exhibited by SW in this project. For the BTRW, it may be valuable to assess tourism numbers and the effect of noise pollution on the den site as it is quite close to the walking track. Overall, assessing the broader landscape in a more holistic way may explain the different aspects to the spatial and temporal separation of these wallaby species.

7.0 Acknowledgements

I would like to thank the Wildlife Preservation Society of Queensland (WPSQ) for accepting me as a placement student. I would like to acknowledge the invaluable knowledge and assistance WPSQ members have provided; Paul Sutton for helping out with field work and discussing project report ideas. I would also like to thank Jake (fellow placement student) and Tim Shields (ICC) in helping with field work. Appreciation is extended to Barbara Triggs who made the scat analysis possible for this project. Additionally, I would like to offer my gratitude to supervisors Catherine Kim (University of Queensland) and Matthew Cecil (WPSQ) for their ongoing patience, academic and systemic support, and guidance throughout this project.

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9.0 Appendix

Appendix 1: Regional Ecosystem Information

Figure A1.1: *Pre-clearing Regional Ecosystem Map of the Flinders-Goolman Conservation Estate.*

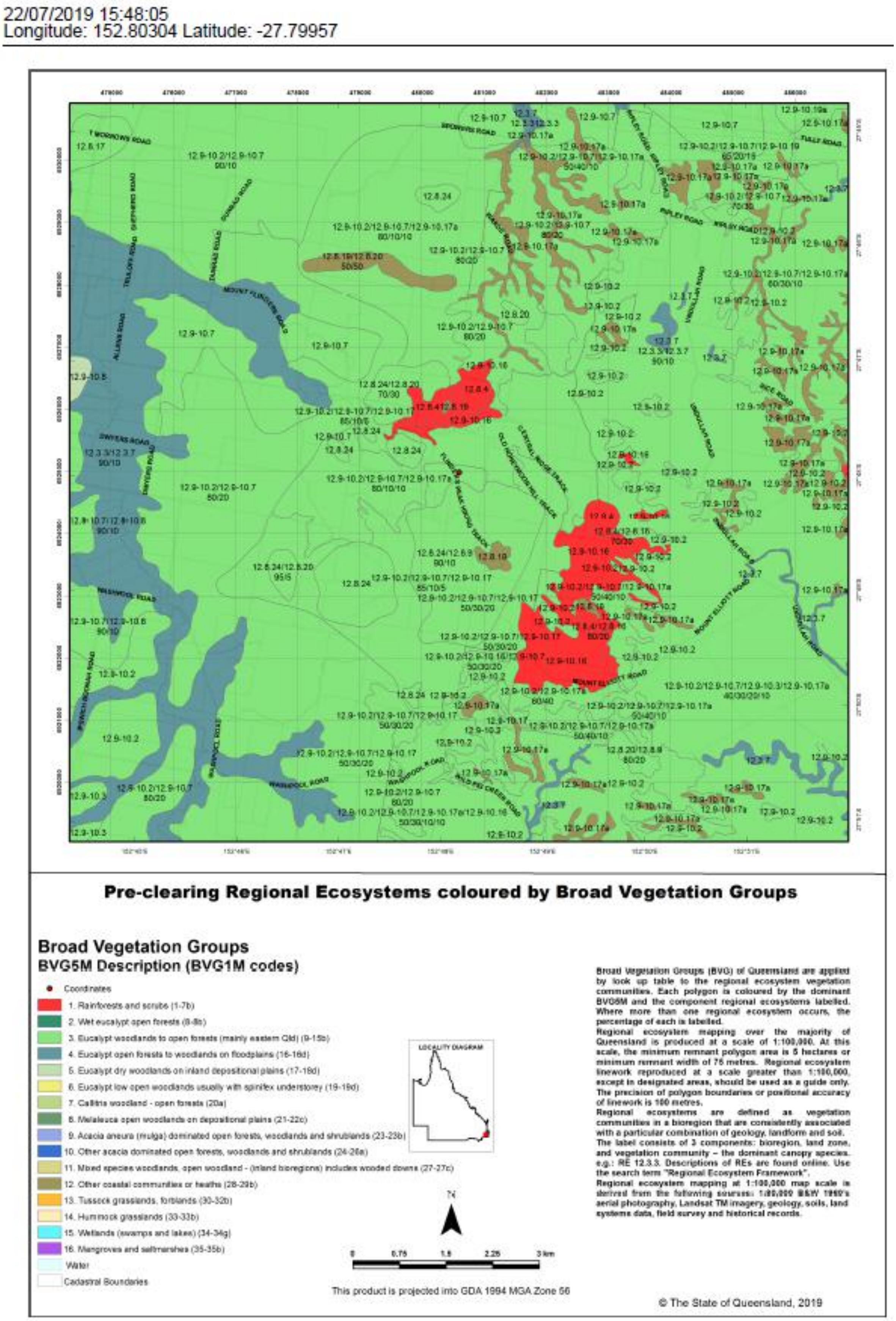


Figure A1.2: *Remnant Regional Ecosystem Map of the Flinders-Goolman Conservation Estate.*

22/07/2019 15:48:05
Longitude: 152.80304 Latitude: -27.79957

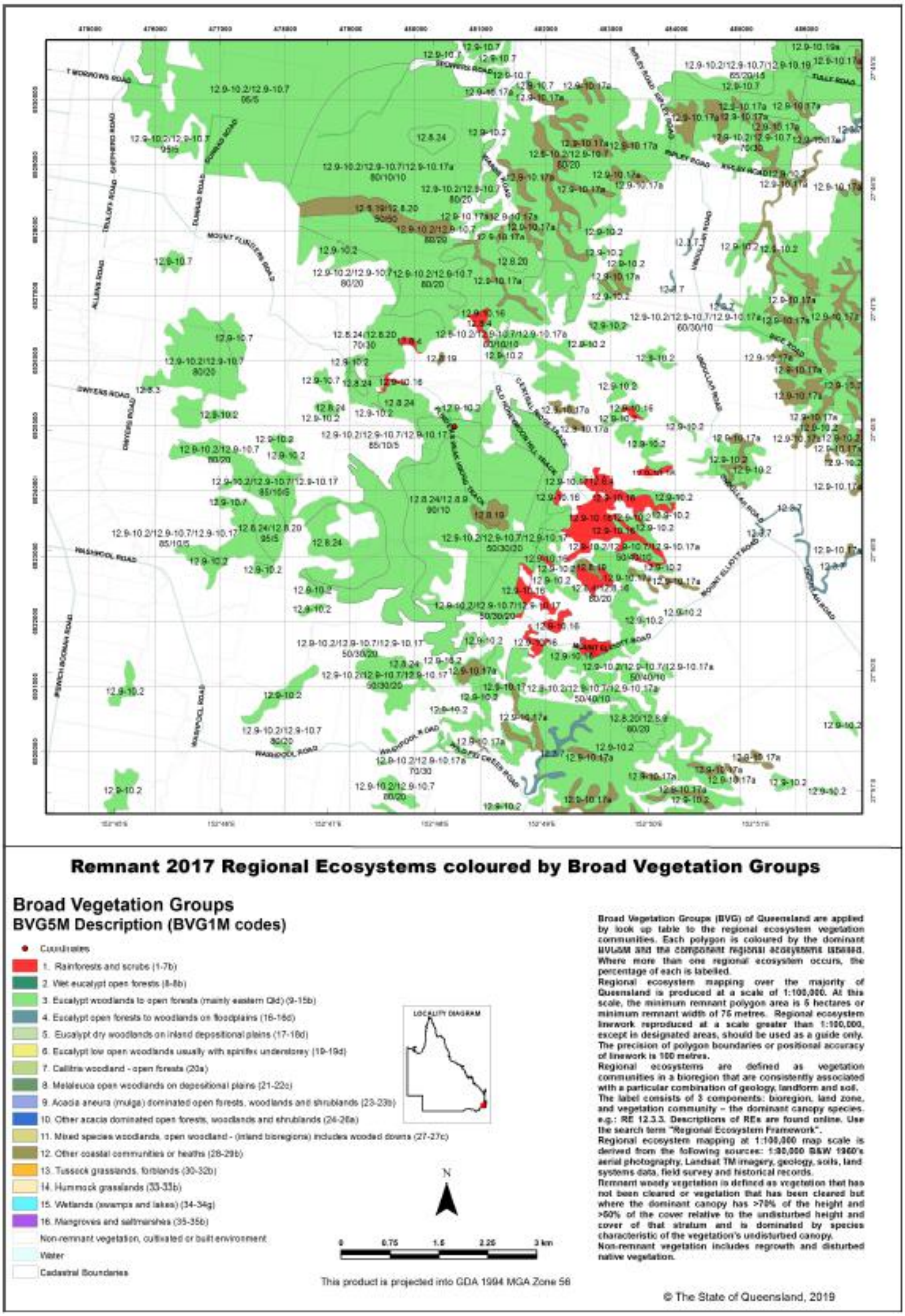


Table A1.3: *Brief Outline of Regional Ecosystem 12.8.9 present in the Flinders-Goolman Conservation Estate. Source: Queensland Government 2019.*

Regional Ecosystem ID	**12.8.9**
Vegetation Management Act Class	Least Concern
Biodiversity Status	Of Concern
Short Description	*Lophostemon confertus* open forest on Cainozoic igneous rocks

Table A1.4: *Brief Outline of Regional Ecosystem 12.8.24 present in the Flinders-Goolman Conservation Estate. Source: Queensland Government 2019.*

Regional Ecosystem ID	**12.8.24**
Vegetation Management Act Class	Endangered
Biodiversity Status	Endangered
Short Description	*Corymbia citriodora* subsp. *variegata* open forest on Cainozoic igneous rocks especially trachyte

Appendix 2: Animal Ethics Approval

Figure A2.1: *Animal Ethics Approval (Wildlife Preservation Society of Queensland).*

Queensland Government	*DAF Animal Ethics*	Form: AE 07
	DECISION of the ANIMAL ETHICS COMMITTEE (AEC)	

1. Applicant (or Applicant contact person) details

Name: Matthew Cecil		
Organisation: Wildlife Preservation Society of Queensland		Centre:
Postal Address: Level 1, 30 Gladstone Road Highgate Hill Qld 4101		
Phone: 3844 0129	Mobile:	E-Mail: wpsq@wildlife.org.au

2. Project Details

Title of the Project	AEC Application Reference Number
Wildlife Queensland: Observation and Monitoring of Wildlife Across Queensland.	**CA 2018/02/1161**

3. AEC Decision

The project application has been considered by the AEC and is:

Approved with conditions

Any inquiry regarding this response should be directed to the AEC Coordinator or Chair in the first instance. The Coordinator or Chair may be contacted via the DAF Call Centre on 13 25 23.

Purpose: Environmental study

Category: Observational studies involving minor interference

Conditions:

Please ensure all relevant equipment is adequately cleaned between sites.

Please note that under the *Biosecurity Act 2014* you have a **general biosecurity obligation** which means you must take all reasonable steps to ensure you do not spread a pest, disease or contaminant. A biosecurity risk exists if you move or keep a pest, disease, contaminant or animal, plant, soil and equipment that could carry a pest, disease or contaminant. You also have an obligation to report unusual events that might be related to biosecurity issues.

This approval only covers procedures documented in the application form. If other procedures are required (eg call playback) please submit an appropriate amendment form.

Period of approval inclusive of the following start and end dates:	Animal type and number approved:
Approved Start Date: 28 February 2018	Various species (excluding fish) and numbers
Approved End Date: 02 June 2020	

Important information

Page 1 of 2 Revised: June 2016

1. **This approval** is for that work as approved in this decision and only within the start and end dates unless amended by a subsequent AEC decision made in accordance with the requirements of the *Animal Care and Protection Act 2001*, the *Australian code for the care and use of animals for scientific purposes* (refer to 2 b) below).

   Any animal use outside this approval will constitute a breach of Section 91 of the *Animal Care and Protection Act 2001* and is subject to a maximum penalty of 300 penalty units or one year's imprisonment.

   As well as obtaining an AEC approval, a person must not use an animal for a scientific purpose unless the person is registered.

   Unless otherwise stated, this approval applies only to work conducted within Queensland.

2. **The AEC requires the Applicant to:**

   a) ensure compliance by all investigators with all conditions set out in this decision in addition to the general requirements of the *Animal Care and Protection Act 2001*, the *Australian code for the care and use of animals for scientific purposes* and all other relevant Commonwealth and State legislation.

   b) submit an Amendment Request (Form AE 08) for any proposed change to a project approval prior to that change being implemented (refer to Procedural Guideline 04);

   c) report any unexpected or adverse event that impacts on the welfare of any animal used in this project (refer to Procedural Guideline 03);

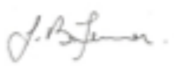
   d) submit Annual Progress Reports (Form AE 10) early each year; and

   e) submit a Project Completion Advice (Form AE 09) upon completion of this project.

3. **Endorsement:** Approval of your project application/amendment request by the AEC is not an endorsement of the project by either the Department of Agriculture and Fisheries or the Queensland Government and is not an endorsement of the Applicant, its products or its processes generally by the AEC, Department of Agriculture and Fisheries or the Queensland Government and no one should assert any such endorsement.

4. **Correspondence:** All correspondence with the AEC in relation to this project should be via email to your AEC contact and cite the name of the Applicant, title of the project and the AEC Application Reference Number.

5. **Grievance:** If the Applicant feels that the AEC has erred in its decision regarding any aspect of the project, the Applicant can submit a complaint (refer to Procedural Guideline 05).

Name of AEC	Community Access AEC
AEC Address	Ecosciences Precinct 41 Boggo Road Dutton Park Qld 4102
Name of AEC Chair	Lex Turner
Chair contact details	T: 07 3708 8507 M: 0427 001 427 email: lex.turner@daf.qld.gov.au
Signature	
Date of Decision	26 February 2018

Page 2 of 2 Revised: Dec 2016

Figure A2.2: *Scientific Purposes Permit.*

Permit

Section 12(f) of Nature Conservation (Administration) Regulation 2017

Scientific Purposes Permit

This wildlife authority is issued under the following legislation: Nature Conservation (Administration) Regulation 2017 Part 2 Division 1.

Permit number: WA0009377 **Valid from:** 26 August 2018 to 25 August 2023

Activity: Taking a protected animal for scientific purposes

Role	Name	Registered address	
Principal Holder:	Wildlife Preservation Society of Queensland	30-34 Gladstone Rd HIGHGATE HILL QLD 4101 Australia	
Person In Charge:	Matthew Cecil		
Business name:		**ABN/ACN**	/
Activity location/licensed premises	State of Queensland		

Schedule

Family or Species or Schedule	Details	Category	Quantity	Unit
Schedule	Wildlife as per the Nature Conservation (Wildlife) Regulation 2006 Schedules 1, 2, 3, 5 and 6	Live	As per condition	Individuals

Jenny Keys
Department of Environment and Science
Delegate of the administering authority
Nature Conservation Act 1992

Date issued: 26 August 2018

Enquiries:
Wildlife Assessment Team
Email: wildlife@des.qld.gov.au
Postal Address: PO Box 102, Toowoomba, QLD, 4350

Page 1 of 1 ABN 46 640 294 485

Queensland Government

Legislative Requirements and Conditions of Wildlife Authority

Nature Conservation

SPPLR01 Permission must be obtained from the landholder prior to commencing activities on freehold/leasehold land.
This requirement may be found in section 99 of the Nature Conservation Act 1992

SPPLR02 This permit (or a copy plus proof of identity of the permit holder) must be carried while engaged in any activity authorised by the permit. Additional assistants can be authorised by the permit holder to undertake the listed activities. Additional assistants must carry a copy of the permit endorsed by the holder with the additional assistants name and residential address and must carry a form of current coloured photographic identification.
This requirement may be found in section 70 of the Nature Conservation (Administration) Regulation 2017

SPPLR03 A return of operations is required to be sent to DES on the approved form or entered directly into Connect, if this is not submitted a penalty may be given.

The required details must be provided within 10 business days of the anniversary date of the permit each year the permit is in force, and within 10 business days of the expiry date.

This information is to be supplied to the Wildlife Assessment Team, Department of Environment and Science, PO Box 102, Toowoomba or sent electronically to wildlife@des.qld.gov.au Please refer to the Wildlife data return information sheet for assistance completing the form, see www.des.qld.gov.au

This requirement may be found in section 222 of the Nature Conservation (Wildlife Management) Regulation 2006.

SPPLR10 Activities carried out under this authority, unless otherwise authorised, apply to non-protected areas only.
This requirement may be found in section 12 of the Nature Conservation (Administration) Regulation 2017

Condition

Nature Conservation

SPPM01 This permit authorises the holder to conduct observational fauna surveys in locations that are not prescribed as Protected Areas under the Nature Conservation Act 1992, in order to investigate the diversity, distribution and abundance of fauna as described in the application.

SPPM03 Activities authorised by this permit must be conducted in accordance with the methods detailed in the Terrestrial Vertebrate Fauna Survey Guidelines for Queensland

SPPM23 A Scientific Purposes Permit Report must be submitted on the standard DES reporting form:
- Within 10 business days of the anniversary date of the permit each year the permit is in force, and
- Within 10 business days of the expiry date.

Figure A2.3: *Animal Ethics Approval Certificate (University of Queensland).*

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Office of Research Ethics
Director
Nicole Shively

Animal Ethics Approval Certificate

19-Aug-2019

Please check all details below and inform the Animal Ethics Unit within 10 working days if anything is incorrect.

Activity Details

Chief Investigator:	Associate Professor Paul Dargusch, Earth and Environmental Sciences
Title:	ENVM3102 Industry Placement (Environmental Management): Wildlife Queensland - Observation and Monitoring of Wildlife Across Queensland (CA 2018/02/1161).
AEC Approval Number:	SEES/346/19
Previous AEC Number:	
Approval Duration:	22-Jul-2019 to 25-Oct-2019
Funding Body:	
Group:	Native and exotic wildlife and marine animals
Other Staff/Students:	Alesia Dyer, Catherine Kim, Matt Cecil
Location(s):	

Summary

Subspecies	Strain	Class	Gender	Source	Approved	Remaining
Other Native Mammals	Various native and exotic species (excluding fish)	Other	Unknown	Other	0	0

Permits

Provisos

Animal numbers are not shown on this certificate as the animals did not die or were not interfered with for the purposes of this project.
Animal numbers are not shown on this certificate as the animals are used for observational studies only and therefore do not require a full approval.

Approval Details

Description	Amount	Balance
Other Native Mammals (Various native and exotic species (excluding fish), Unknown, Other, Other)		
19 Aug 2019 Initial approval	0	0

Animal Ethics Unit
Office of Research Ethics
The University of Queensland

Cumbrae-Stewart Building
Research Road
St Lucia Qld 4072 Australia

+61 7 336 52925 (Enquiries)
+61 7 334 68710 (Enquiries)
+61 7 336 52713 (Coordinator)

animal.ethics@research.uq.edu.au
uq.edu.au/research

Please note the animal numbers supplied on this certificate are the total allocated for the approval duration

Please use this Approval Number:

1. When ordering animals from Animal Breeding Houses
2. For labelling of all animal cages or holding areas. In addition please include on the label, Chief Investigator's name and contact phone number.
3. When you need to communicate with this office about the project.

It is a condition of this approval that all project animal details be made available to Animal House OIC. (UAEC Ruling 14/12/2001)

The Chief Investigator takes responsibility for ensuring all legislative, regulatory and compliance objectives are satisfied for this project.

This certificate supersedes all preceding certificates for this project (i.e. those certificates dated before 19-Aug-2019)

Animal Ethics Unit
Office of Research Ethics
The University of Queensland

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Research Road
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uq.edu.au/research

Appendix 3: Species List for a Specified Point

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: Animals
Type: All
Status: All
Records: All
Date: All
Latitude: -27.7995
Longitude: 152.8030
Distance: 5
Email: mattcecil@wildlife.org.au
Date submitted: Monday 22 Jul 2019 16:03:31
Date extracted: Monday 22 Jul 2019 16:10:13

The number of records retrieved = 149

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		1
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		1
animals	amphibians	Limnodynastidae	*Adelotus brevis*	tusked frog		V		2
animals	amphibians	Myobatrachidae	*Mixophyes fasciolatus*	great barred frog		C		1
animals	birds	Acanthizidae	*Gerygone olivacea*	white-throated gerygone		C		2
animals	birds	Acanthizidae	*Acanthiza pusilla*	brown thornbill		C		2
animals	birds	Acanthizidae	*Sericornis frontalis*	white-browed scrubwren		C		4
animals	birds	Acanthizidae	*Acanthiza reguloides*	buff-rumped thornbill		C		1
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		3
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		4
animals	birds	Accipitridae	*Accipiter novaehollandiae*	grey goshawk		C		1
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		7
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		15
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		3
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		5
animals	birds	Artamidae	*Strepera graculina*	pied currawong		C		9
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		10
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		7
animals	birds	Cacatuidae	*Calyptorhynchus funereus*	yellow-tailed black-cockatoo		C		1
animals	birds	Cacatuidae	*Eolophus roseicapilla*	galah		C		2
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		5
animals	birds	Campephagidae	*Lalage leucomela*	varied triller		C		1
animals	birds	Campephagidae	*Coracina tenuirostris*	cicadabird		C		3
animals	birds	Charadriidae	*Vanellus miles novaehollandiae*	masked lapwing (southern subspecies)		C		3
animals	birds	Climacteridae	*Cormobates leucophaea metastasis*	white-throated treecreeper (southern)		C		1
animals	birds	Climacteridae	*Cormobates leucophaea*	white-throated treecreeper		C		3
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		5
animals	birds	Columbidae	*Chalcophaps indica*	emerald dove		C		1
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		2
animals	birds	Columbidae	*Macropygia amboinensis*	brown cuckoo-dove		C		4
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		1
animals	birds	Columbidae	*Lopholaimus antarcticus*	topknot pigeon		C		2
animals	birds	Columbidae	*Leucosarcia melanoleuca*	wonga pigeon		C		4
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		3
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		11
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		2
animals	birds	Cuculidae	*Cacomantis flabelliformis*	fan-tailed cuckoo		C		2
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		3
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		1
animals	birds	Cuculidae	*Chalcites minutillus barnardi*	Eastern little bronze-cuckoo		C		1
animals	birds	Dicruridae	*Dicrurus bracteatus*	spangled drongo		C		5
animals	birds	Estrildidae	*Neochmia temporalis*	red-browed finch		C		1
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		1
animals	birds	Eurostopodidae	*Eurostopodus mystacalis*	white-throated nightjar		C		2
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		2
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		3

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Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Falconidae	*Falco peregrinus*	peregrine falcon		C		3
animals	birds	Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra		C		5
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		1
animals	birds	Hirundinidae	*Hirundo neoxena*	welcome swallow		C		1
animals	birds	Maluridae	*Malurus cyaneus*	superb fairy-wren		C		3
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		1
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		9
animals	birds	Megapodiidae	*Alectura lathami*	Australian brush-turkey		C		1
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		5
animals	birds	Meliphagidae	*Acanthorhynchus tenuirostris*	eastern spinebill		C		1
animals	birds	Meliphagidae	*Myzomela sanguinolenta*	scarlet honeyeater		C		7
animals	birds	Meliphagidae	*Manorina melanocephala*	noisy miner		C		9
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		3
animals	birds	Meliphagidae	*Meliphaga lewinii*	Lewin's honeyeater		C		7
animals	birds	Meliphagidae	*Caligavis chrysops*	yellow-faced honeyeater		C		4
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		C		4
animals	birds	Monarchidae	*Symposiachrus trivirgatus*	spectacled monarch		SL		2
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		6
animals	birds	Monarchidae	*Myiagra rubecula*	leaden flycatcher		C		1
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		1
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		4
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		2
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		4
animals	birds	Oriolidae	*Sphecotheres vieilloti*	Australasian figbird		C		4
animals	birds	Orthonychidae	*Orthonyx temminckii*	Australian logrunner		C		1
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		4
animals	birds	Pachycephalidae	*Colluricincla megarhyncha*	little shrike-thrush		C		1
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		2
animals	birds	Pachycephalidae	*Pachycephala pectoralis*	golden whistler		C		7
animals	birds	Pardalotidae	*Pardalotus punctatus*	spotted pardalote		C		7
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		5
animals	birds	Petroicidae	*Petroica rosea*	rose robin		C		2
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		1
animals	birds	Petroicidae	*Eopsaltria australis*	eastern yellow robin		C		7
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		2
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		2
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		1
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		2
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		4
animals	birds	Psittacidae	*Trichoglossus chlorolepidotus*	scaly-breasted lorikeet		C		4
animals	birds	Psittacidae	*Alisterus scapularis*	Australian king-parrot		C		2
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		4
animals	birds	Psophodidae	*Cinclosoma punctatum*	spotted quail-thrush		C		2
animals	birds	Psophodidae	*Psophodes olivaceus*	eastern whipbird		C		6
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus violaceus*	satin bowerbird		C		1
animals	birds	Rhipiduridae	*Rhipidura rufifrons*	rufous fantail		SL		3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		6
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		6
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		3
animals	birds	Strigidae	*Ninox strenua*	powerful owl		V		2
animals	birds	Sturnidae	*Sturnus vulgaris*	common starling	Y			4
animals	birds	Sturnidae	*Acridotheres tristis*	common myna	Y			5
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		1
animals	birds	Timaliidae	*Zosterops lateralis*	silvereye		C		6
animals	birds	Turnicidae	*Turnix melanogaster*	black-breasted button-quail		V	V	1
animals	insects	Hesperiidae	*Hesperilla sarnia*	swift sedge-skipper				1
animals	insects	Hesperiidae	*Toxidia parvula*	banded grass-skipper				1
animals	insects	Hesperiidae	*Toxidia peron*	dingy grass-skipper				1
animals	insects	Hesperiidae	*Netrocoryne repanda repanda*	bronze flat (southern subspecies)				1
animals	insects	Hesperiidae	*Neohesperilla xanthomera*	yellow grass-skipper				1
animals	insects	Hesperiidae	*Hesperilla crypsigramma*	wide-brand sedge-skipper				4
animals	insects	Lycaenidae	*Nacaduba biocellata biocellata*	two-spotted line-blue				1
animals	insects	Lycaenidae	*Hypochrysops delicia delicia*	moonlight jewel (eastern subspecies)				1
animals	insects	Lycaenidae	*Acrodipsas brisbanensis*	bronze ant-blue				3
animals	insects	Lycaenidae	*Ogyris zosine zosine*	northern purple azure (southern subspecies)				1
animals	insects	Lycaenidae	*Candalides sp.*					2
animals	insects	Lycaenidae	*Ogyris olane*	broad-margined azure				1
animals	insects	Lycaenidae	*Acrodipsas cuprea variabilis*	copper ant-blue				1
animals	insects	Nymphalidae	*Hypocysta metirius*	brown ringlet				1
animals	insects	Nymphalidae	*Tisiphone abeona rawnsleyi*	varied sword-grass brown (Queensland subspecies)				1
animals	insects	Nymphalidae	*Charaxes sempronius sempronius*	tailed emperor				1
animals	insects	Nymphalidae	*Acraea andromacha andromacha*	glasswing				1
animals	insects	Papilionidae	*Graphium macleayanum macleayanum*	Macleay's swordtail				1
animals	insects	Papilionidae	*Protographium leosthenes leosthenes*	four-barred swordtail				1
animals	insects	Pieridae	*Delias nigrina*	black jezebel				1
animals	insects	Pieridae	*Cepora perimale scyllara*	caper gull (Australian subspecies)				1
animals	mammals	Dasyuridae	*Phascogale tapoatafa tapoatafa*	brush-tailed phascogale		C		3
animals	mammals	Dasyuridae	*Antechinus flavipes flavipes*	yellow-footed antechinus (south-east Queensland)		C		1
animals	mammals	Macropodidae	*Macropus parryi*	whiptail wallaby		C		2
animals	mammals	Macropodidae	*Petrogale penicillata*	brush-tailed rock-wallaby		V	V	28
animals	mammals	Macropodidae	*Macropus rufogriseus*	red-necked wallaby		C		2
animals	mammals	Molossidae	*Tadarida australis*	white-striped freetail bat		C		1
animals	mammals	Petauridae	*Petaurus breviceps*	sugar glider		C		1
animals	mammals	Phalangeridae	*Trichosurus caninus*	short-eared possum		C		1
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	25
animals	mammals	Potoroidae	*Aepyprymnus rufescens*	rufous bettong		C		1
animals	mammals	Pteropodidae	*Pteropus poliocephalus*	grey-headed flying-fox		C	V	1
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		1
animals	mammals	Suidae	*Sus scrofa*	pig	Y			2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	ray-finned fishes	Eleotridae	*Mogurnda adspersa*	southern purplespotted gudgeon				1
animals	reptiles	Agamidae	*Diporiphora australis*	tommy roundhead		C		1/1
animals	reptiles	Boidae	*Morelia spilota*	carpet python		C		1
animals	reptiles	Colubridae	*Dendrelaphis punctulatus*	green tree snake		C		1
animals	reptiles	Diplodactylidae	*Diplodactylus vittatus*	wood gecko		C		1
animals	reptiles	Scincidae	*Cryptoblepharus pulcher pulcher*	elegant snake-eyed skink		C		6
animals	reptiles	Scincidae	*Calyptotis scutirostrum*	scute-snouted calyptotis		C		1
animals	reptiles	Scincidae	*Anomalopus verreauxii*	three-clawed worm-skink		C		1/1
animals	reptiles	Scincidae	*Lygisaurus foliorum*	tree-base litter-skink		C		1
animals	reptiles	Scincidae	*Carlia vivax*	tussock rainbow-skink		C		1
animals	reptiles	Scincidae	*Carlia sp.*					1
animals	reptiles	Scincidae	*Morethia taeniopleura*	fire-tailed skink		C		1
animals	reptiles	Varanidae	*Varanus varius*	lace monitor		C		2
animals	uncertain	Indeterminate	*Indeterminate*	Unknown or Code Pending		C		1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992*. The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999*. The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

10.0 Reflection

The industry placement I undertook this semester has been a challenging but valuable experience. Throughout my placement at WPSQ I have been presented with various tasks, with the most complicated task being my overall project for the semester. Most of the placement experience was new to me; I have never worked in an office setting before, never been involved with a non-government organisation, and I've never had to completely design and manage a project and project budget. Office tasks were simple and straightforward for the most part, but if there was ever a point where I was unsure of something I just asked and double-checked the process to dealing with the problem. Most of the challenges and new experiences came from the project itself, particularly the management side of things.

The most significant learning experience from my placement was the writing up of the actual report in terms of interpreting the data/conducting data analysis. It was quite difficult to decide on exactly what data I wanted to present, how I wanted to present it in order to communicate inferences and patterns I was observing, and how to conduct this in a way that addressed my aims/objectives. I thought the data analysis would be simple and straightforward, and I think this was because I am used to writing up prac reports or scientific experiments that have clear aims, outputs and data that can be statistically analysed. My project on the other hand was a very observational project, with the aims changing from the project brief to the final report, and even changing while writing the final report. The data I collected was not able to be statistically analysed, as it was largely observational ecological data that was used to inform management decisions rather than to prove/disprove a hypothesis. My project was very flexible, and completely driven by me to adapt my project to the data I was collecting, which normally I thought I was pretty good at being flexible, but the data analysis really challenged my attitude towards this.

Because the data was not suitable for statistical analysis, it took me a while to get my head around what kind of analysis I could conduct. I didn't realise the data wasn't suitable for statistical analysis at the start, and so I spent a lot of time playing around with different analysis options that were statistical. In doing this alone, I ended up stuck on a data loop with no new ideas, and a lack of understanding why my data couldn't be analysed the way I wanted, and it was quite frustrating. At some point I realised that I should ask for help. I was worried that by doing so the answer would be something completely different to what I'd already done, and I didn't want my hard work and data manipulation to go to waste, so I didn't ask for help for a little while. I am occasionally stubborn, and so reflecting on this struggle with data analysis I realise I was having a stubborn approach to overcoming the analysis problem by myself. However, it was really frustrating me and eventually I was so lost in the loop I reached out to various people for an outside opinion because I was completely stumped. I realised that by doing this they could give fresh ideas and perhaps they have more experience with analysing my type of data than I did. I asked my supervisor Matt, my fellow placement students, my academic supervisor and I also emailed the authors of articles conducting projects very similar to mine. This was very valuable as the census across the board was that the data analysis should focus on visual patterns, since it is unsuitable for statistical analysis because of a lack of statistical indpendence. I received very useful papers from one of the authors regarding analysis options for camera trap data, which set me on a good path and gave me direction for what to do with my data. Matt also suggested creating a heatmap to visualise spatial patterns, which I would never have thought of since I hadn't covered heatmaps in my degree so far. I knew how they worked though, and with some googling I had a very informative representation of the data. Asking other people to help is a very valuable option when you are stuck on something; I remember reading a paper once about multidisciplinary approaches to environmental management, and the value of differing experience in knowledge working together on one problem, and in this case it was a practical example of how people from different academic backgrounds can provide direction and solutions when they combine their opinions. This is partly what drove me to ask for help, since I was stuck, and I clearly needed assistance.

Similar to the struggles with data analysis, I faced a challenge with vegetation data for my project as well. However, this was a slightly different situation since I am quite limited in my vegetation knowledge, but I am extremely aware of this. With my limitations I was much more ready to ask for assistance straight off the bat, rather than "waste" my time trying to do it solo. I think this was because with data analysis I like to think I understand it a little more, and therefore thought I could solve the problem with my own knowledge base. I think this is what led me to be reluctant to ask for help compared to the vegetation data where I didn't even attempt anything solo. Stubbornness is a trait of mine, so I am not surprised that I attempted to work through the data analysis by myself. I will need to be aware of this in future and know where my limitations are and when to ask for help in order to be the most time efficient I can.

Apart from learning technical skills like GIS and field techniques, I feel like the most valuable skills I have taken away from this is the ability to 'humble' myself, overcome my stubborn approach to solving problems and ask for help and accept the constructive criticism that comes my way by doing that. Also, the ability to let go of previous hard work in order to create something more informative and valuable (like my data manipulation that wasn't useful for the report after asking second opinions on analysis options).

By designing and managing my own field-based project, my project management skills were further developed. I am quite happy with how I dealt with the size of the project. Time management is crucial in projects such as these, and I feel I excelled with this, even despite the analysis setbacks. I have good organisation skills and I feel that this project enhanced my ability to be flexible, organised and I feel it only strengthened my time management skills. I pride myself on my organisation and time management skills and this project was a nice confirmation of some of my strengths.