THARRA GREATER BILBY CONSERVATION PROJECT

Fauna Report

February 2025

BUDADEE ABORIGINAL CORPORATION

Acknowledgement of Country

We acknowledge the Palyku people, who are the Traditional Custodians of Tharra (Woodstock Protected Reserve) and the areas described within this report. We pay our respects to the Elders past, present, and emerging, and to their continuing cultural and spiritual connections to their lands.

This report leans heavily on the Traditional Knowledge of the Palyku people of the central Pilbara, whose knowledge is shared with permission.

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1. Background

The Pilbara Environmental Offset Fund (PEOF), administered by the Department of Water and Environmental Regulation (DWER), provides funding for environmental offset projects as a counterbalance to impacts from Pilbara activities. This is delivered in partnership with regional programs (including ranger teams), to provide offset projects targeted towards strategic, landscape-scale priority targets.

The Woodstock Abydos Protected Reserve (WAPR), located within the Chichester sub-bioregion, falls within the PEOF's Priority Area 1 for offset projects. The reserve is protected under section 19 of the *Aboriginal Cultural Heritage Act 2021 (WA)* and represents a high concentration of priority environmental matters required to be offset. The southern half of the reserve (Tharra) lies within the Palyku Native Title Determination Area. Tharra is actively managed by the Budadee ranger team, a Palyku owned and operated Caring for Country program administered by Budadee Aboriginal Corporation (Budadee).

On-country consultation between DWER and Budadee was held in 2022 and identified areas for collaboration towards environmental offset objectives. One such opportunity was in the protection of habitat for the Greater Bilby (*Macrotis lagotis*). Greater Bilby (bilby) habitat is recognised as a Matter of National Environmental Significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and is a condition in Ministerial Statements which the PEOF is required to offset. For Budadee, concerns have been high that bilby habitat at Tharra is threatened by increasing levels of development, introduced species and a lack of fire management.

The Tharra Greater Bilby Conservation Project was co-designed by DWER and Budadee with the aim of establishing Tharra as an actively managed refuge for identified bilby populations. As the first stage of a larger management program, this project targeted knowledge gaps in our understanding of the bilby population of Tharra, defining their area of occupancy and providing a baseline data set for bilby monitoring. The groundwork was also laid for assessing the management priorities required for protecting bilby habitat in stage two of the project.

A survey methodology for assessing bilby occupancy was designed based on established occupancy modelling for bilbies in the Pilbara, and desktop research was conducted to predict potential distribution across Tharra (past survey effort, bilby ecology, vegetation and substrate structure, refer to Tharra Greater Bilby Conservation Project, Desktop Research 2023, Appendix 3). A three-day reconnaissance survey was then conducted in August 2023 with Palyku Elders and knowledge holders to refine the field methodology and map indicative survey plot areas using a combination of traditional knowledge and predicted distribution. Access limitations across Tharra, known avoidance areas (cultural avoidance areas) and additional habitat indicators were also assessed and recorded.

Between October 2023 and June 2024, the Budadee rangers undertook four five-day field surveys to collect track-based survey data on bilby occupancy across Tharra. A total of 240 hectares were surveyed across Tharra from 64 individual 2 ha plot sampling locations (56 of which were surveyed twice). At selected areas of recent

bilby activity, motion-sensor cameras were also established to capture visual confirmation of bilby presence. This document is a field survey report presenting the results of these surveys. In line with the strategy of the Greater Bilby Conservation Project, it has the following objectives:

- Identify bilby occupancy within Tharra
- Delineate priority bilby habitat within Tharra
- Establish baseline data and a monitoring approach to evaluate bilby habitat and quantify changes to bilby occupancy over time
- Assess key threatening processes to bilby habitat and identify management priorities.

2. Project Logic

Species profile

The Greater Bilby (*Macrotis lagotis*) is a medium-sized, desert marsupial endemic to Australia. It is the only remaining species from the family Thylacomyidae, after the other known member, *Macrotis leucura,* was declared extinct in the 1960s (Jackson and Groves 2015). From a historical distribution that covered more than three quarters of Australia's landmass, the bilby is now only found within northern deserts of Western Australia and the Northern Territory, and from one small population in south-west Queensland. It is estimated that this distribution reflects less than 20% of their former range, with a declining population of fewer than 10,000 mature individuals (Southgate 1990; Woinarski et al. 2014). Bilbies are listed as vulnerable under the *Biodiversity Conservation Act 2016 (WA)* and the EPBC Act and are listed as vulnerable under the IUCN Red List of Threatened Species (IUCN Red List of Threatened Species, 2015). The bilby is one of 100 priority species selected as part of the Australian Government's Threatened Species Strategy.

Across their known distribution, bilby habitat is characterised by sandplains, claypans, dune fields, laterite, mulga bushland, and creeklines, preferring spinifex (*Triodia spp*.) grasslands and medium/soft substrate (Woinarski et al. 2014). Bilbies are primarily nocturnal and cover large individual ranges in search of food and shelter (Woinarski et al. 2014). They are omnivorous, with a diet consisting of invertebrates, seeds, bulbs and fungi and they typically dig for their food, burrowing to a depth of two and a half metres (Gibson 2001). Bilbies have extensive foraging ranges and move across country, using numerous burrows scattered across the landscape (Moseby and O'Donnell 2003). It is not uncommon for bilbies to travel distances of 3 to 5 km in a single day (Southgate and Carthew 2007).

Tharra is located along the southwestern boundary of the bilby's estimated current distribution (Recovery Plan for the Greater Bilby 2023). It contains a range of habitat

suitable for supporting bilby populations and bilby signs (sightings, tracks, scats and burrows) have been documented from historical surveys dating back to the 1960s.

Bilbies have long been recognised as being part of Tharra's landscape. Palyku people have a strong knowledge of the animals on Palyku Country, including bilbies. Palyku people, especially the old people, understand the country, and the conditions and habitat that support bilbies.

On Palyku Country, there are many bush foods that are eaten by bilbies. This includes insects, *bardi* (large insect larvae i.e. witchety grubs), seeds, fruits, and tubers. The presence and relative abundance of these foods on country can signal suitable bilby habitat, infer the health of country, and help to refine survey effort. Bilbies find food from different sources in different areas of Palyku Country. Understanding and identifying these sources across Palyku Country can help to define and protect bilby habitat.

Plate 1: Gnarlgu (Cyperus bulbosa) were commonly found dug up adjacent to bilby burrows and are an important part of the bilbies diet at Tharra.

Within Tharra's river systems and along drainage lines, bilbies dig for *bardi* in the roots of trees such as *wantanypa* (*Acacia aneura*) and *munduru* (*Acacia cyperophylla*) and for termites amongst *baru* (spinifex, *Triodia wiseana*). They will dig for the tuberous roots of *ngarlgu* (bush onions, *Cyperus bulbosa)* sometimes digging out the whole plant. Roots and seeds of bush carrot (*Daucus glochidiatus*), *mungalin* (*Iponoea spp*.), bush bean (*Vigna lanceolata*), *marta* (sweet bush potato, *Dioscorea hastifolia*) and *ngarbruda (*bush cucumber, *Cucumis melo*) also provide a food and water source.

On *baru* country (spinifex flats), bilbies dig for termites and *bardi*, particularly on recently burnt country. Plants that have *bardi* on *baru* country include *budadee* (*Acacia inaequilatera)*, *jiggarda* (*Eucalyptus leucophloia*), *burgu* (*Hakea lorea)* and cockroach bush (*Senna notabilis)*. Bilbies may also eat the *wogola* (bush coconuts) fallen from the *bunara* tree *(Corymbia opaca).* Fruits from *galumbu* (bush tomato, *Solanum phlomoides*), and *wanyalie* (bush banana, *Marsdenia australis*) may also be eaten.

> "At Woodstock [Tharra], [bilbies] gotta be in soft country. Mostly on the banks of the creeks. Food they eat is the *bardi* (witchety) grub. In amongst the mini ritchi on the riverbanks. Soft soil to dig. *Bardi* grub is the main food. They break the roots open. They travel around a bit, size of a rabbit. Travel a fair bit. They go and come back. The mini ritchi needs the soft sand as well, in Woodstock there, well, where their burrows are, not far away are the mini ritchi. When we look around, we'll see the *bardi* diggings." – Kevin Stream (pers. comm. 29/06/2023).

Plate 2: Bilby diggings under a young mini ritchi tree on a riverbank at Tharra

Regional Context

The Pilbara region represents a significant refuge for bilbies, lying at the southwestern boundary of their known range (Recovery Plan for the Greater Bilby 2023). The Pilbara's spinifex-dominated grasslands and sandy plains provide ideal conditions for bilbies to forage, burrow, and shelter (Woinarski et al. 2014). As omnivores, bilbies have an opportunistic diet, consuming various invertebrates, seeds, bulbs, roots, fungi, and fruit (Southgate, 1990; Gibson, 2001; Johnson, 2008). The Pilbara bilby population is thought to be mostly concentrated across the eastern half of the region, with modern data suggesting that their population range boundary is located about 50 km west of Port Hedland and extends southeast of Newman (Dziminski et al. 2020).

Comparative Studies

Comparative studies across Western Australia have found bilby occupancy levels to vary depending on habitat type and survey methods. Bilby occupancy modelling uses plot surveys and repeat sampling to account for imperfect detectability, to estimate bilby occupancy to create a and a detection probability value. For example, on the Dampier Peninsula, 44 sign plots were surveyed, with bilbies detected in 10 plots (23%), using a combination of 2 ha sign plot surveys and remote sensing methods to account for imperfect detectability (Dziminski & Bettink, 2017). Other comparative studies across Western Australia report relatively low occupancy rates in the Fitzroy catchment (0.21, detection probability 0.49) and La Grange (0.22, detection probability 0.42), while Matuwa showed similar occupancy (0.32) but with lower detectability (0.18) due to vegetation variation (Dziminski et al., 2018; Lohr et al., 2021). At Warralong, motion-sensor cameras recorded an occupancy of 0.31, but 2 ha sign plot surveys yielded lower values (0.05–0.1, detectability 0.46) (Dziminski, Carpenter & Cowan, 2021). Future studies with further comparative analysis with other populations could assist with refining regional conservation strategies.

Regional Threats

Grazing Pressure

Cattle grazing has been identified as a potential threat to bilby in both Queensland (Morton & Newsome 1994) and regions of the eastern Pilbara and Dampierland (Southgate 1990). While some studies contest the impact of grazing on bilbies in Queensland (Lavery & Kirkpatrick 1997), the ongoing decline in bilby populations highlights the need for adjustments in landscape management to support their long-term survival (Pavey, 2006).

Erosion, soil compaction, and the loss of native vegetation reduce food and burrow availability for bilbies, while artificial water points created for pastoralism and industry facilitate the spread of predators, fragment bilby populations, and increase numbers of introduced herbivores (McRae, 2004; Bradley et al., 2015; Northover et al., 2023). The bilby's current distribution in Australia is linked to areas with low or no pastoral activity and rabbit presence (Bradley et al., 2015). In the Pilbara, over

60% of habitat is now pastoral land, with the vast majority for cattle (DPaW, 2017). While Morton (1990) suggested that medium-sized arid fauna, like the bilby, decline due to their reliance on productive substrates that attract herbivores, studies by Southgate et al. (2007) and McDonald et al. (2015) found no clear link between substrate type and bilby presence, but indicated negative impacts from cattle grazing and high rabbit densities. Both DBCA (2021) and Southgate (1990) found an adverse relationship between bilby occupancy and cattle occupancy. Within Tharra, grazing disturbance varies across the landscape, with cattle impacts frequently occurring alongside areas that are already under existing disturbance such as near roads, railway lines and other infrastructure, around water sources and along river systems (Budadee Aboriginal Corporation, unpublished ranger reports 2022 - 2024).

Predation

Introduced predators have been key drivers of the decline and extinction of Australia's terrestrial mammals, including the bilby (Woinarski et al., 2015). The two main animals that predate bilbies being foxes and feral cats. European red fox presence adversely impacts bilby populations within the Pilbara, with their presence majorly attributed to the bilby's demise in the south-west (Abbott, 2001; Southgate, 1990). While Northover et al. (2023) notes that foxes are currently absent in northern WA, they remain present in the Fitzroy and Ord Valleys and the Pilbara, particularly along coastal areas and major drainage lines (King & Smith, 1985; DPaW, 2017). Feral cats, which prey on bilbies, are present across much of the Pilbara (Carwardine et al., 2014). Predator-prey interactions are crucial in shaping ecosystems, with nonlethal predator effects, such as injuries or behavioral changes, reducing prey fitness (Chen et al., 2024; Peacor & Werner, 2001; Hammill et al., 2015). The perception of predation risk, even in the absence of direct threats, influences prey behavior, including social activities, feeding habits, and vigilance (Hunter & Skinner, 1998; Lima & Bednekoff, 1999). For bilbies, increased predation risk can lead to reduced activity and altered behavior, such as less time spent foraging or socialising (Chen et al., 2024; Dall et al., 2001; Blanchard et al., 2017). Chen et al. (2024) demonstrated that the presence of cats affects bilby behavior for several days, reducing their digging activity, which in turn impacts ecosystem processes, such as soil properties and plant germination, with broader implications for the Pilbara's flora and fauna. CSIRO modelling projects that without further management, 25% of significant conservation species may be extinct from the region within 20 years (Carwardine et al., 2014; Northover et al., 2023).

Altered Fire Regimes

Altered fire regimes, particularly the cessation or reduction of traditional cultural burning practices, have contributed to the decline of small and medium-sized mammals, including the bilby, across northern and central Australia (Burbidge & McKenzie, 1989; Woinarski et al., 2001; Cramer et al., 2016). In areas left unburnt, dense old vegetation dominates, reducing food availability and increasing

intense wildfire risk (Palyku Elders, 2023). In regions like the Western Desert, fire regimes have shifted from a fine-grained mosaic to larger, more intense burns, which can disrupt bilby habitat and reduce cover, increasing predation risk (Burrows et al., 2006; Cramer et al., 2016). However, bilbies show some adaptability to different fire-age habitats, with the ability to recolonise areas burnt within six months, though their activity is influenced by the availability of unburnt refuges (Thompson & Thompson, 2008; Southgate et al., 2007). Recurrent hot fires, especially in combination with grazing, can promote conditions favoured by introduced predators like cats, further threatening bilby populations (McGregor et al., 2014; Cramer et al., 2016).

Infrastructure

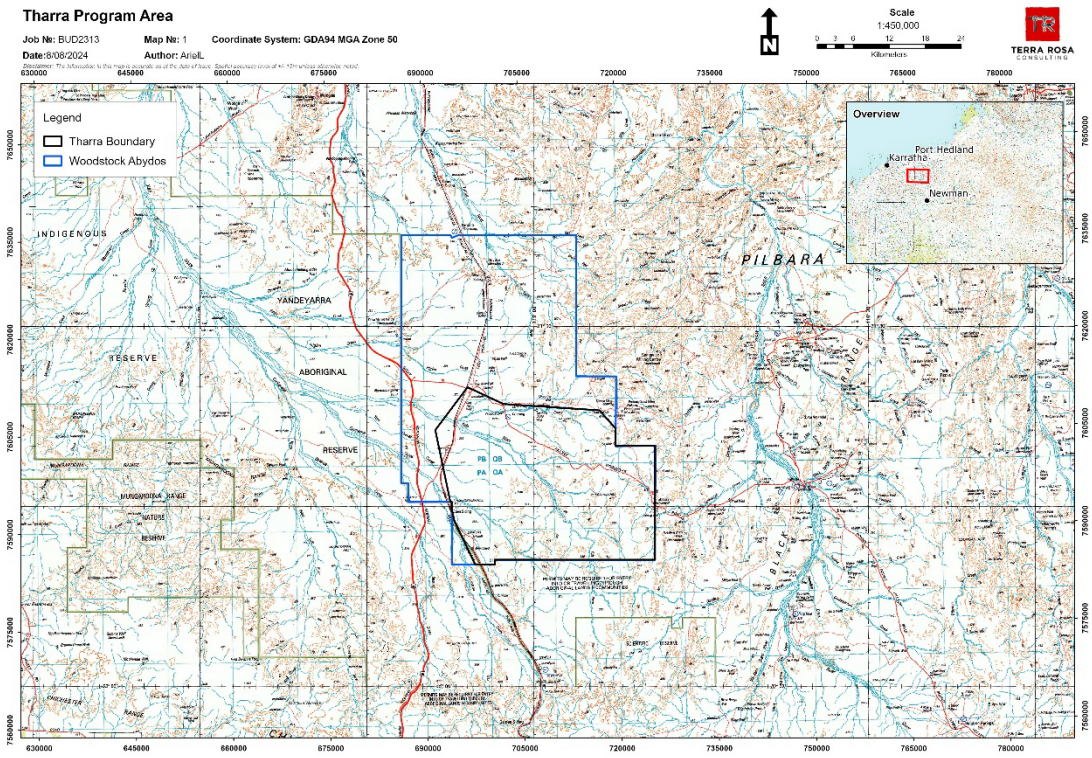
Infrastructure, including roads, fences, dams, mines, and agriculture, poses various threats to bilbies through habitat loss, increased roadkill risk, and barriers to dispersal and gene flow, while also often increasing predator densities due to additional food and water resources (Bradley et al., 2015; Northover et al., 2023). Vehicle and train collisions, alongside artificial noise and light are also a direct disturbance to bilby populations (Gardner, 2013; BHP, 2016). The small, fragmented nature of bilby populations limits their resilience and genetic fitness, making them more vulnerable to extinction on a local level (DCCEEW, 2023). Additionally, the interaction of road and railway in conjunction with other factors such as introduced predators, grazing, and fire, requires further investigation (McGregor et al., 2014; Northover et al., 2023).

Each regional pressure uniquely impacts bilby habitat and food availability. However, limited studies on bilby habitat use and diet in the Pilbara have resulted in knowledge gaps regarding the influence of substrate, landform, and food availability on habitat suitability (Northover et al., 2023; Cramer et al., 2017). While it is understood bilbies can adapt to variations in resource levels due to their motility and opportunistic feeding strategy, how they respond to the dynamic alterations of resources in the Pilbara is still uncertain. (Gibson, 2001; Southgate et al., 2007; Cramer et al., 2017).

Project area

Tharra Karnparnmana (also known as the Woodstock Abydos Protected Reserve) is a 154,102 ha heritage reserve located in the Chichester bioregion of the central Pilbara. Its borders represent the amalgamation of the historic Abydos and Woodstock pastoral properties, that were merged into a single reserve before being recognised for protection under the *Aboriginal Heritage Act 1972 (WA).* Tharra (*pronounced duh-ra)* refers to the Country of the Palyku Traditional Owners within the reserve and falls within the Palyku Native Title Determination Area (WC1998/071). Tharra covers an area of approximately 74,000 hectares and includes the southern and eastern half of the amalgamated reserve, roughly analogous with the historic Woodstock pastoral station boundary. Upper catchments of the Yule and Shaw Rivers snake though

Tharra, with water collecting in numerous permanent and semi-permanent rock holes and springs. Tharra is a place of enormous cultural significance, with songlines, engravings, and stories that connect Palyku people to their law, culture, and community.



Map 1: Tharra program area and Woodstock Abydos Protected Area boundary.

Tharra is dominated by gently undulating stony and sandy plains, punctuated by granite ranges. It is intersected by two river systems, the upper catchment of the Yule River and the Shaw branch of the De Grey River. Tharra's plains typically support a shrub steppe of *budadee (Acacia inaequilatera)* over *baru* (spinifex) hummock grasslands *(Triodia wiseana)* with tree steppes of *jiggarda* (white wood tree, *Eucalyptus leucophloia)* dominating the ranges. A shade of *dalgoolbooda (Malaleuca spp.)* and *munduru* (*Acacia cyperophylla)* is common across the river systems, with banks dominated by *baru* (*Triodia wiseana)* and introduced buffel (*Cenchrus cilliaris*) grasses.

Pre-survey desktop research identified habitat with suitable geological and biological characteristics for bilbies across an estimated 63,000 hectares (or 85% of Tharra). This includes Macroy, Granitic, River and Boolaloo Land Systems (refer to table 1). Historical survey data reveals documented records of bilbies from 21 secondary sign sightings (tracks, burrows, and scats) between 1969 and 2017. These sightings are skewed towards the northern sections of Tharra with 16 within Macroy and four within River Land Systems. These recordings are primarily focussed on road and rail

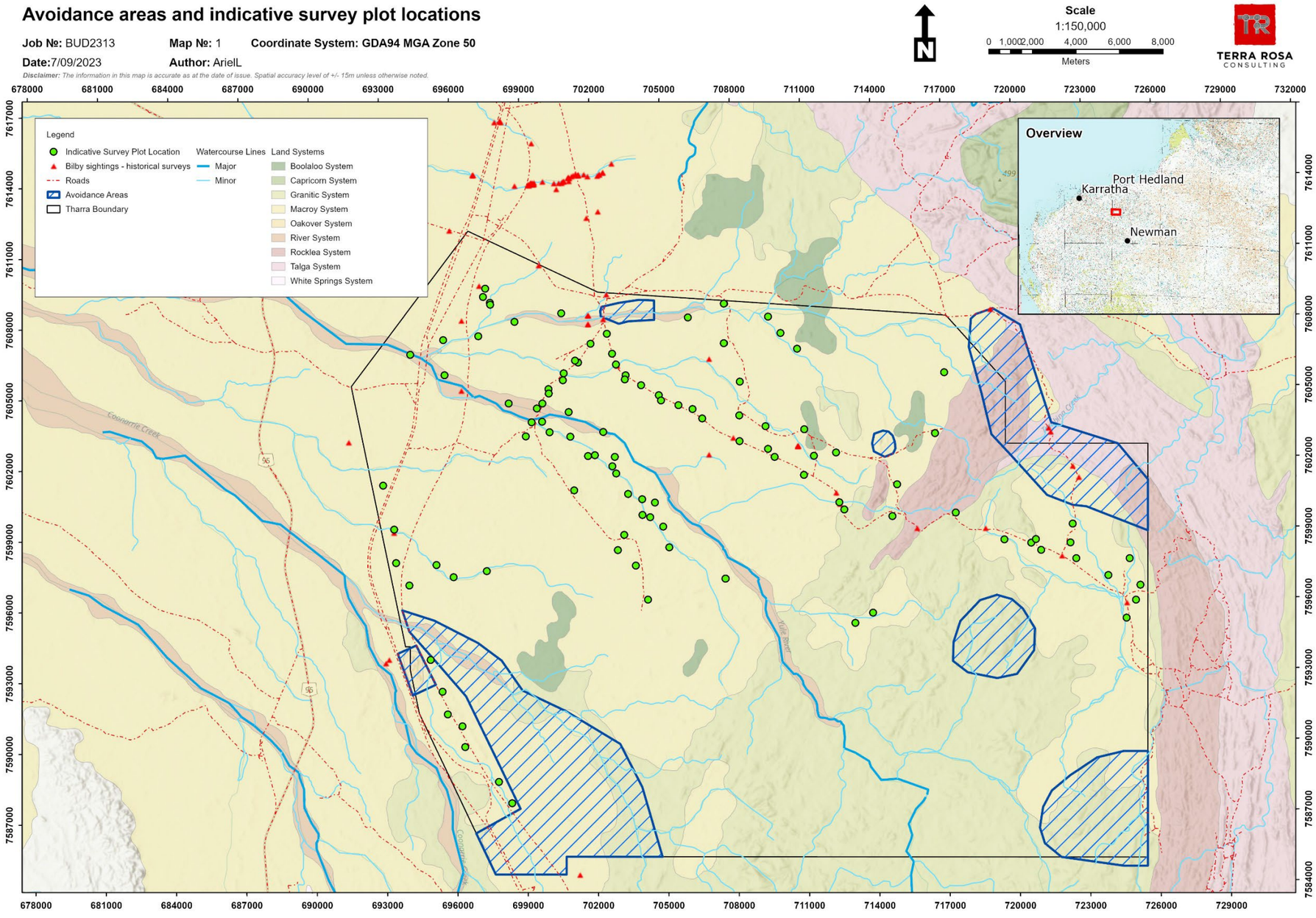
infrastructure corridors (reflective of survey effort). For example, 14 of the documented sightings within Tharra represent surveys conducted in 2014 adjacent to the Hillside-Woodstock Road. Data is sourced from the following databases:

- Threatened and Priority Fauna (DBCA-037)
- Atlas of Living Australia
- Index of Biodiversity Surveys for Assessments (IBSA)
- Protected matters search tool – heatmap
- NatureMaps (pre-2021 data).

Table 1: Representative coverage (estimate) of major Land Systems within Tharra with potential bilby habitat highlighted in green.

Land Systems within Tharra		Tharra coverage
Macroy	Stony plains and occasional tor fields based on granite supporting hard and soft spinifex shrubby grasslands.	~45%
Boolaloo	Granite hills, domes, tor fields and sandy plains supporting spinifex grasslands with scattered shrubs.	<5%
Granitic	Rugged granitic hills supporting shrubby hard and soft spinifex grasslands.	~35%
River	Narrow, seasonally active flood plains and major river channels supporting moderately close, tall shrublands or woodlands of acacias and fringing communities of eucalypts sometimes with tussock grasses or spinifex.	<5%
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex and occasionally soft spinifex grasslands with scattered shrubs.	<10%

Map 1: Historical bilby sightings at Tharra and proposed 2 ha survey plot sampling locations showing identified cultural avoidance areas and Land Systems.



Methodology

Ground-based assessment of bilby presence was undertaken using the 2 ha sign plot method. Two ha sign plots are a method of track-based survey that standardises survey effort and area. The 2 ha sign plot method allows direct comparisons between plots and enables estimations on the probability of detection and occupancy (Southgate et al. 2019). Coupled with systematic re-sampling to control for detection probability, the 2 ha sign plot method is the recommended approach for large area surveys (>1600 ha) that require quantifiable data (DBCA 2018). The methodology has a few limitations that should be noted. It is labour intensive, requiring field-based surveys with suitably trained personnel. It provides limited information on individuals or measurements of abundance, and plot allocation is skewed to areas with suitable access (for example within proximity of roads and tracks). Despite these limitations, it remains an effective method for detecting bilbies, was deemed the most suitable survey method for the project area and is widely used to detect bilbies and define bilby occupancy (DBCA 2018, Southgate 1990, Paltridge 2016).

The 2 ha sign plot methodology was used to define detection and occupancy of bilbies at Tharra. Detection here is defined as the probability of detecting evidence of the focal species given the species uses the location, and occupancy is defined as the proportion of locations used by the species (Moore 2022). Given the relative scarcity of bilbies within landscapes, and the large defined project area at Tharra (~74,000 ha), a suitably large number of plots was sampled to ensure data collected is statistically robust (n=120). A total of 64 plots were assigned across four potential habitat zones. These were ground-truthed and allocated during an initial reconnaissance survey (August 2023), considering traditional ecological knowledge, cultural protocols (for example avoidance areas), range of post-fire aged habitat, suitable soil type and access limitations across country (refer to map 2).

The 2 ha sign plot surveys were conducted over four, 5-day field trips by a team of Budadee rangers (refer to table 2 and table 3). Survey effort was focussed within survey plots with a defined area of 200 m by 100 m (2 ha), with observers searching for bilby and feral predator signs (such as tracks and scats) for a set duration of 25 minutes (adjusted for team size). Observations of bilby signs were captured on a custom digital survey form (refer to plate 4, alongside observation data on heritage values, fire age, threatening processes and any indicator species relevant to bilbies (such as food sources). Other information relevant to ongoing management of Tharra was collected as identified including other priority listed species (priority flora, conservation-listed fauna), species of cultural importance (traditional land-use species such as ceremony, food and medicine species) and any undocumented heritage values. Each plot was photographed from the southwest corner, and GPS points and track logs were captured.

Table 2: Field survey dates

Survey Name	2 ha plot numbers	**Date**
Field Survey 1	1 – 30	10 – 15 October 2023
Field Survey 2	31 – 60	6 – 11 November 2023
Field Survey 3	Replicates 1 – 30	12 – 17 March 2024
Field Survey 4	Replicates 31 – 56 New plots 61 – 64	27 May – 01 June 2024

To insure against issues of imperfect detectability, sampling was replicated at 56 of the 64 plots approximately four months after the baseline survey (refer to table 2). Four sites established in 2023 were not replicated in 2024 after advice from Palyku Elders on cultural sensitivities in the area, and instead four new plots were established.

Plate 3: Fresh bilby scats identified at active burrows during field surveys.

Where high confidence in recent bilby activity was detected, motion-sensor cameras were set up to detect bilby and feral predator activity. A total of three cameras (Reconyx HS2X Hyperfire 2) were established adjacent to recent bilby activity outside of survey plot 30 (refer to map 3). One camera was set in May 2023 (BC01), and two cameras were set in July 2024 (BC02, BC03). These were collected and reviewed in November 2023 (BC01) and September 2024 (BC02, BC03). A total of 41 nights in 2023, and 24 nights in 2024 were monitored across the three cameras, equating to a total of 65 survey nights. Each camera was fixed firmly to a 1.5 m black galvanised star picket and oriented horizontally relative to active bilby burrow sites. Cameras were set to high sensitivity, taking bursts of three photos with a 15 second (photo-free) interval. No bait was used.

Table 3: Project participants

Budadee rangers	Position	Field survey
Natalie Stream	Senior Ranger/Cultural Advisor	1
Gavin Cabales	Ranger Coordinator/Cultural Advisor	1, 2, 3, 4
Hazel Lockyer	Ranger	1, 3
Duane Stream	Ranger	1
Keniesha Cabales	Ranger	1, 2
Damien Ball	Ranger	1, 3
Michael Coffin	Ranger	1, 3, 4
Zakiesha Clinch	Ranger	1, 3, 4
Margaret Stewart	Ranger	1, 3
Stephen Stewart Snr	Elder	1, 2, 3
Biddy Norman	Elder	1
Fred Stream	Elder	1
Annabel Stream	Ranger/Cultural Advisor	1, 2, 3
Steven Stewart Jnr	Ranger	1, 2, 3
Weston Stream	Ranger	1
Madison Fraser	Ranger	1
James Dolin	Ranger Coordinator	1, 2, 3, 4
Danika Penson	Environmental Consultant	1
Andrew Hatswell	Consultant	2, 4
Judith Giraldo	Environmental Consultant	2
Amanda Stream	Ranger	2
Diana Flanagan	Ranger	2
Kylie Ryan	Ranger	2, 3, 4
Leo Cabales	Ranger	2
Leroy Clinch	Ranger	2
Sandra Francis	Ranger	2
Stan Ball Jnr	Ranger	2
Brandon Dhu	Ranger	3, 4
Catherine Biljabu	Ranger	4
Raylene Robinson	Ranger	4
Hayley Malana	Ranger	4
Valerie Aspro	Ranger	4
Janissa Booth	Ranger	4
Tasma Francis	Ranger	4

Data management

Two-hectare survey plot data was recorded in-field using a custom 2 ha survey form through Survey123 (ArcGIS) and recorded on Samsung tablets (see plate 4 for an example). This form was designed using standard fields for threatened species surveys provided by the Department of Biodiversity, Conservation and Attractions (DBCA) and reviewed by DBCA's Animal Science team prior to deployment. Additional spatial data, including the location of the survey plots and placement of motion-sensor cameras, was collected on handheld GPS devices (Garmin GPS). All collected data, including digital and field notes, were uploaded to Budadee's secure SharePoint System for later analysis.

Motion-sensor camera images were uploaded to Budadee's photo library on SharePoint from relevant SD cards and reviewed by the Budadee ranger team on-country for an initial assessment. These will be made available to DBCA once they have been formally reviewed by Budadee's ranger coordinators.

Cultural information, including photos and spatial data, was vetted in situ by elders and/or relevant Palyku knowledge holders and, when appropriate, were restricted or deleted as necessary.

Plate 4: Example page from the digital survey form designed to capture bilby signs.

Data Analysis

Occupancy modelling was undertaken by the DBCA courtesy of Dr Harry Moore and Natasha Harrison (Biodiversity and Conservation Science). Statistical analysis was undertaken using the unmarked R package (R v4.4.1) using a single-season occupancy model that accounts for imperfect detectability and occupancy (Mackenzie et al. 2002, Moore 2022). This was done by adjusting the naïve occupancy (i.e. non-adjusted proportion of locations used by focal species) with a measure of detectability. The parameter ψ (occupancy, i.e. the probability that site *i* is occupied by the focal species) and *p* (detection probability, i.e. the probability of the focal

species being detected at site *i* on day *j,* conditional upon its presence) was used to formulate the occupancy model.

A range of occupancy covariates (i.e. covariates influencing occupancy probability) were considered. These were grazing pressure (impact of grazing on habitat quality), substrate type (type of ground surface for example clay or sand), and time since burn (the time elapsed since the last fire event, hereby referred to as tsb). A fourth covariate, feral cat presence, was recorded in situ but not included in analysis due to discrepancies in data collection across sites and limited available data. No detectability covariates were used in this study.

The occupancy model selection was based on Akaike's Information Criterion corrected for small sample sizes (AICc). Models with lower AICc values were considered better fits to the data, balancing model complexity and explanatory power (pers. comm. Dr Harry Moore July 2024).

It should be noted that the occupancy model works under the assumptions that a) detection of species at sites is independent of detection at other sites; b) there are no false detections and c) occupancy remains constant over the sampling period. Due to restrictions of access and the large number of sites sampled over a relatively small area, site independency cannot be safely ensured (many sites were sampled less than the recommended 2 km distance from each other). In addition, the 2024 survey events were separated by a three-month period due to inclement weather, potentially affecting the constant occupancy assumption. Whilst these discrepancies are hard to measure, it is of the professional opinion of the author and analysis team at DBCA that these effects are likely not sufficient to undermine the validity of the model and analysis results.

3. Results

Field surveys collected data from a total of 64 sites, 56 of which were surveyed twice and eight sites surveyed only once (a total of 120 plot surveys). From these sites, positive detection of bilby presence was recorded from a total of 22 survey plots across 16 sampling plot locations, 14 during the first sampling events (October and November 2023) and 8 during the second (replicate sampling event, March and June 2024, refer to figure 1). Bilby signs recorded included tracks, diggings, burrows, and scats. Naïve occupancy was recorded at 0.34 (number of sites detected divided by total number of sites sampled). Detectability was recorded at 0.61, indicating that there is a 61% probability of detecting bilbies if they are present in the surveyed area. This relatively high detectability suggests that the methods used for surveying were effective in identifying the presence of bilbies.

Plate 5: Active bilby burrow with fresh tracks detected during field surveys.

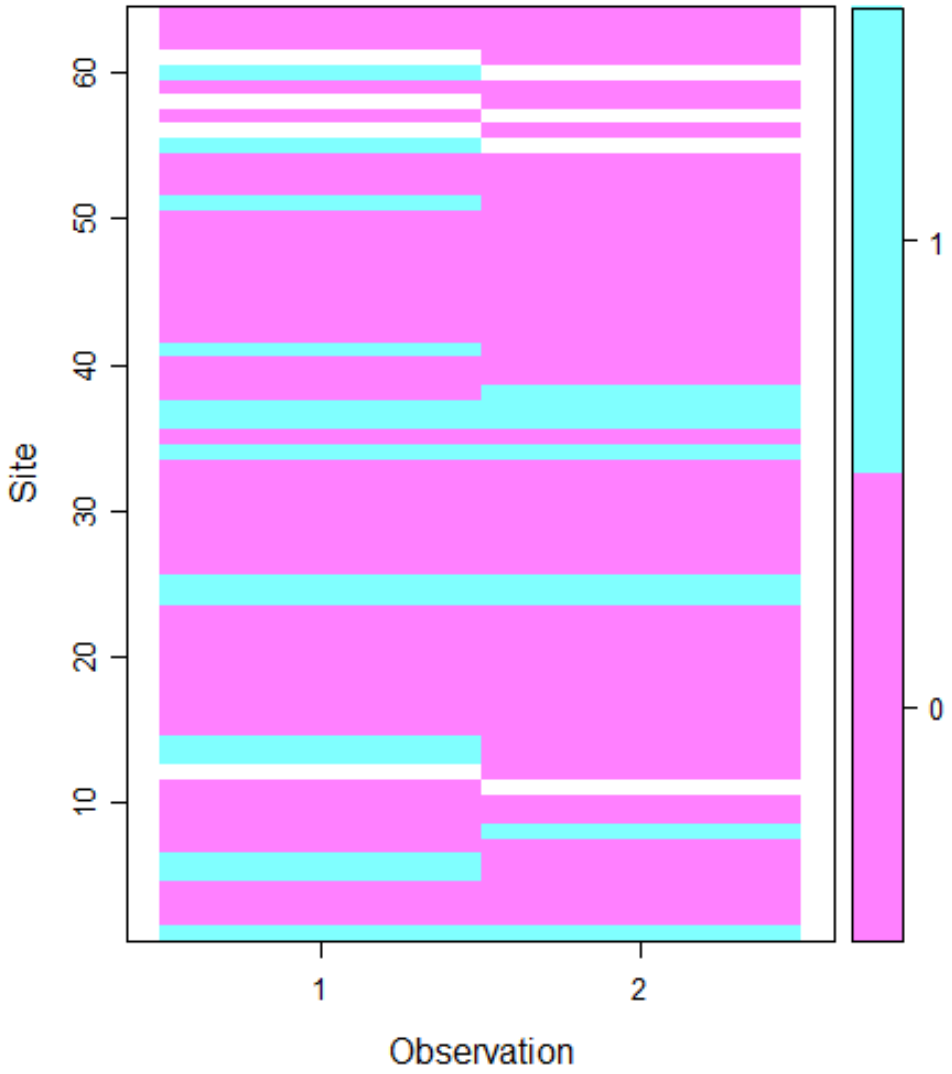


Figure 1. Detection history of bilbies across 64 sites and two survey events. Each row represents a different site, while each column represents a survey event. Blue bars indicate detected presence (1) of bilbies, and pink bars indicate non-detection (0). White bars indicate no survey was undertaken at that site. Courtesy of DBCA.

Positive detections of bilby presence were distributed broadly across Tharra, with sightings along the eastern, northwestern and western margins of the reserve, as well as two positive detections in the centre (refer to map 3). The highest proportion of positive detections were located to the northwest, with eight sightings located within a five km radius of Rabbitohs Well (see plot 40, map 3 for reference). Almost all detections were found within Macroy Land Systems, typified by stony plains and occasional tor fields based on granite supporting hard and soft spinifex shrubby grasslands. Two detections (plots 30 and 58) were in River Land Systems adjacent to Macroy Land Systems.

Motion-sensor cameras were established adjacent to active bilby burrows at three locations close to survey plot 30, near Rabbitohs Well (refer to map 3 and table 4). Vegetation condition at these sites was considered poor, with obvious signs of damage caused by human activities including grazing, aggressive weeds (*Vachelia farnesiana)* and clearing for infrastructure. These sites are also close to road and rail infrastructure.

Table 4: Camera location and habitat information

Reference Location Number	Land System	Condition Score (EPA)	Site	Coordinates	
				Latitude	Longitude
BC01	Macroy	Poor	Tharra	-21.612140	118.9096882
BC02	Macroy	Poor	Tharra	-21.611144	118.9091246
BC03	Macroy	Poor	Tharra	-21.611194	118.9086327

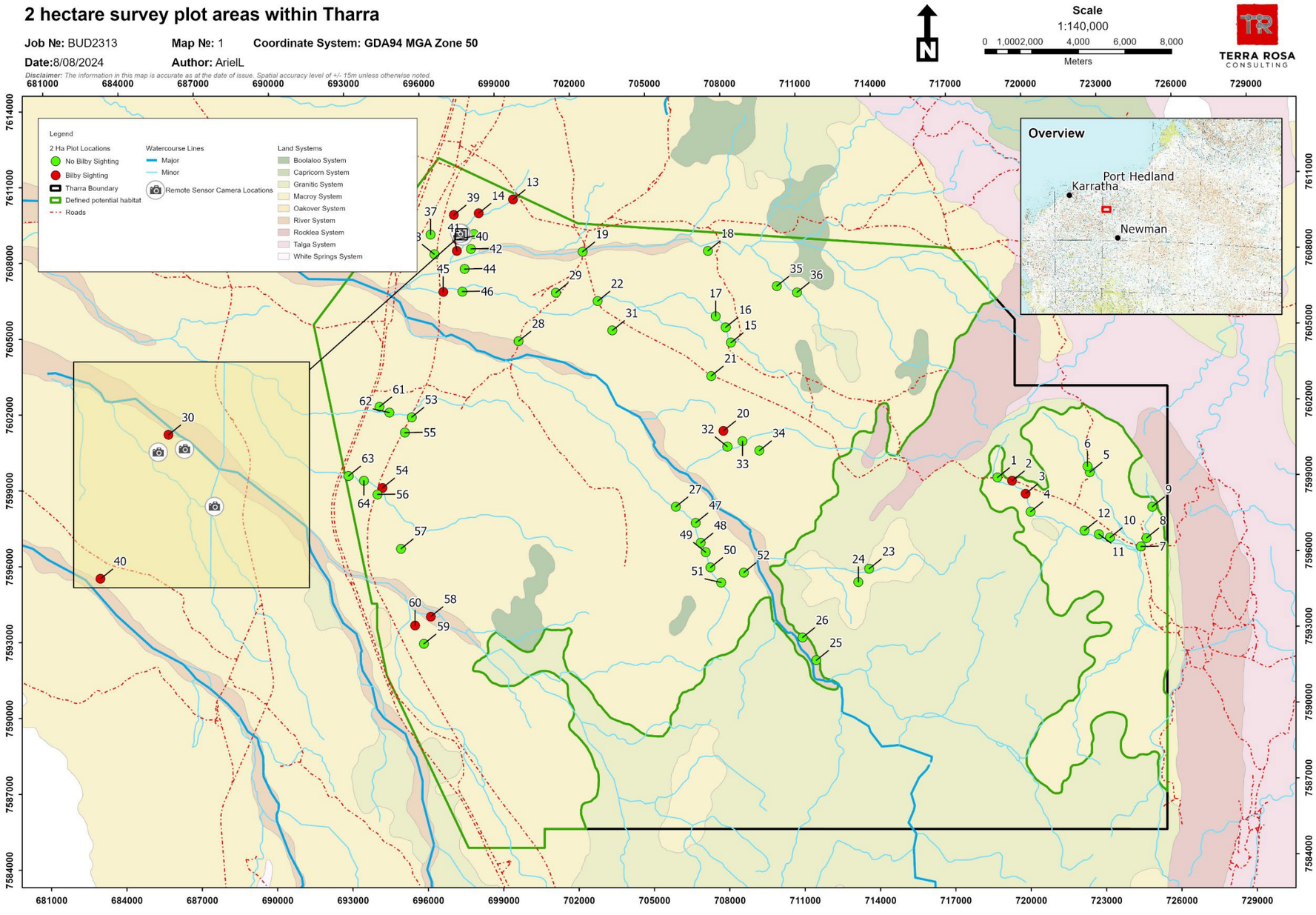
BC01, BC02 and BC03 have been reviewed for the 2023/2024 survey season, noting bilby presence and introduced predators and herbivores. Across the three cameras a total of 4434 photos were taken over 65 days. BC01 took 3179 photos over a 49-day period, including 2070 photos of bilbies, 1 photo of a dingo, and 304 photos of feral cats. BC02 took 1005 photos over a 21-day period, including 170 photos of bilbies, 407 photos of dingoes, 4 photos of cattle, and 20 photos of a feral cat (single individual). BC03 took 250 photos over a 3-day period, including 11 photos of bilbies (refer to table 5).

Table 5: Remote sensor camera detections

Date Range	Reference Location Number	No. of photos with a Bilby present	No. of photos with a Dingo present	No. of photos with a Cat present	No. of photos with Cattle present	No. of photos with a Fox present	Total No. of Photos taken
25/05/2023-12/07/2023	BC01	2070	1	304	0	0	3179

26/07/2024-15/08/2024	BC02	170	407	20	4	0	1005
24/07/2024-26/07/2024	BC03	11	0	0	0	0	250

Map 3: 2 ha survey plot locations, showing areas of recorded bilby sightings and placement of motion-sensor cameras.



Single-season occupancy modelling was undertaken on the field data, based on Akaike's Information Criterion corrected for small sample sizes (AICc). The occupancy covariates of grazing pressure, substrate type, and time since burn (tsb), as well as interactions between covariates, were assessed to determine the best fit for final model selection. Of these, grazing pressure was identified as the best fit for the model (AICc=103.9, refer to table 6).

Table 6: Occupancy model selection table (courtesy of DBCA).

Formula	***p(Int)***	***psi(Int)***	***df***	***AICc***	***delta***
~ 1 ~ Grazing_pressure	0.45	-2.01	4	103.90	0.00
~ 1 ~ Grazing_pressure + tsb	0.45	-1.55	5	105.79	1.89
~ 1 ~ Grazing_pressure	0.44	-0.82	2	106.61	2.72
~ 1 ~ Grazing_pressure + tsb	0.45	-0.15	3	107.31	3.41
~ 1 ~ Grazing_pressure + Substrate	0.47	-7.84	7	107.74	3.84
~ 1 ~ Substrate	0.43	-7.69	5	109.30	5.40
~ 1 ~ Grazing_pressure + Substrate + tsb	0.48	-5.89	8	110.29	6.39
~ 1 ~ Substrate + tsb	0.44	-4.24	6	110.89	6.99

The final model included data from all 64 sites, of which 56 were surveyed twice and eight were surveyed once. Under the grazing pressure model, low grazing pressure significantly increased species presence (estimate = 2.89, SE = 1.42, z = 2.04, p = 0.04, refer to table 7 and figure 2).

Table 7: Summary of top occupancy model (courtesy of DBCA).

	Estimate	*SE*	*z*	*P(>|z|)*
(Intercept)	-2.01	1.08	-1.86	0.06
Grazing pressure - Low	2.89	1.42	2.04	0.04
Grazing pressure - Medium	0.93	1.15	0.81	0.42

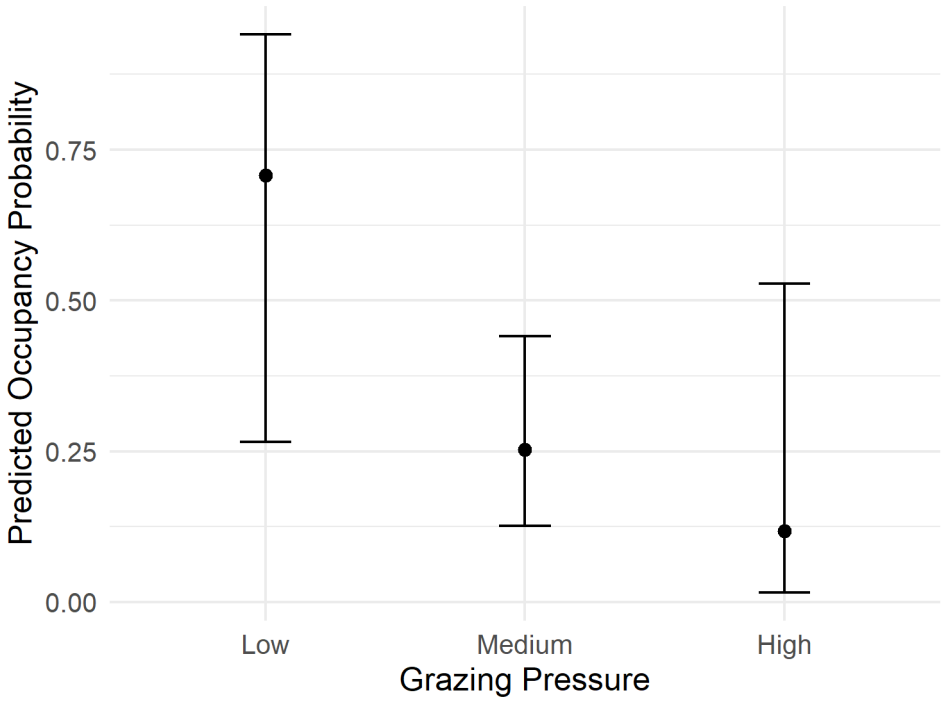


Figure 2: Predicted bilby occupancy in response to grazing pressure (courtesy of DBCA)

4. Discussion and Management Recommendations

As part of the Woodstock-Abydos Protected Reserve, Tharra is well placed to act as a refuge for the Greater Bilby. However, to actively manage the reserve and ensure proposed management effort was suitable or indeed even needed, significant knowledge gaps on Tharra's bilby ecology had to be addressed. Principle questions included, but are not limited to:

- Are bilbies still present in the landscape?
- How widespread is this presence across Tharra?
- What, if any, threats to bilbies exist at Tharra that need to be managed?
- How can we be sure that management effort is having a positive effect?

To address these questions, a coordinated survey effort was undertaken using best-practice survey methodology, in combination with traditional ecological knowledge. Specifically, survey methods and cultural knowledge captured aimed to:

- Identify bilby occupancy within Tharra;
- Delineate priority bilby habitat within Tharra;
- Establish baseline data and a monitoring approach to evaluate bilby habitat and quantify changes to bilby occupancy over time; and
- Assess key threatening processes to bilby habitat and identify management priorities.

Occupancy

The presence of bilbies was confirmed with 22 positive detections across Tharra within survey plots. The 2 ha sign plot field surveys, and subsequent occupancy modelling, were used to calculate bilby occupancy within Tharra. Specifically, the occupancy modelling identified the probability of presence of bilbies using repeat surveys to account for imperfect detectability. Based on the modelled occupancy and detection probabilities, bilby occupancy was estimated at 0.34 with a per survey detection probability of 0.61. In other words, bilbies can be expected to use 34% of surveyed 2 ha plots in the project area, and provided that a plot was used by a bilby, there is a 61% chance that that presence would be detected by the survey team in a single survey event.

Similar occupancy studies have been undertaken for bilby presence in Western Australia including the Fitzroy catchment region (Dziminski et al. 2021), La Grange area (Dziminski et al. 2018), Warralong (Dziminski, Carpenter and Cowan 2021), and at Matuwa (Lohr et al. 2021). Bilby occupancy at Tharra was estimated to be higher than the Fitzroy catchment region (occupancy of 0.21, with a survey detection probability of 0.49), and the La Grange area (occupancy of 0.22, survey detection

probability of 0.42), and comparable to Matuwa (occupancy of 0.32, detectability 0.18, but highly variable detectability based on vegetation structure covariates). It should be noted that Matuwa's occupancy modelling was based on motion-sensor cameras as opposed to track-based surveys, and thus may not be directly comparable.

Though not explicitly targeting bilbies, comparable levels of bilby occupancy were also detected from motion-sensor cameras at Warralong (approximately 200 km northeast of Tharra). Occupancy at Warralong was 0.31 from detections using 30 motion-sensor cameras, though occupancy from similar detections using 2 ha sign plot surveys (30 plots) was much lower, ranging from 0.05 to 0.1, with a detectability of 0.46 (Dziminski, Carpenter & Cowan 2021).

The results of the track-based surveys and occupancy modelling confirms that Tharra is an active habitat for bilbies, inclusive of foraging and burrowing habitats. The high level of occupancy and detectability relative to survey effort suggest that bilby occupancy at Tharra may be higher than typically recorded in the Pilbara and warrants continued survey effort to better understand density and distribution throughout the reserve.

Priority Habitat

A primary objective of the Tharra Greater Bilby Conservation Project is to delineate priority areas of bilby habitat within Tharra, for the purpose of allocating future management effort. The occupancy of 0.34, reflective of the large number of positive detections of bilbies (22 detections across 16 sampling locations), coupled with the relatively broad distribution of sightings across the survey area (some separated by 20 km), suggests that Tharra is broadly occupied by bilbies, at least within Macroy Land systems (approximately 32,400 ha). Positive detections of bilbies were found in *baru* country, and typically close to riverbanks (within 1 km). In all identified locations potential or confirmed food sources were identified by the ranger team, most notably *ngarlgu* (bush onions, *Cyperus bulbosa*) and *munduru* roots (*Acacia cyperophylla*). It should be noted that survey effort was largely skewed towards river systems due to access constraints (see map 3).

The distribution of positive detections across Tharra suggests the presence of multiple areas of occupancy occupied by different individuals. Estimates of short-term home range sizes in the Northern Territory have been found to vary from 1.1 to 3 km^2 (Southgate and Possingham 1995), and between 0.18 and 3.16 km^2 for females and males respectively in South Australia (Moseby and O'Donnell 2003). At Tharra, positive detections of bilbies tended to occur in high frequencies relative to a central plot (for example see plots 13, 14, 39 40, 41 and 42, map 3) or separated by distances of often more than 10 km. The highest frequencies of positive detections were found within a roughly 5 km radius of plot 40 (7 positive detections). This area lies close to the northwest boundary of Tharra and within 1 km of road and rail infrastructure. Other detections were located along the west and southwest margins (plot 54, 58 and 60), near ephemeral drainage lines towards the centre of the reserve (plot 20), and east of Mount Webber (plot 2 and plot 3), albeit at lower frequencies. Plots 2 and 3 are separated from the next nearest positive detection by 12 km, most of which is terrain deemed unlikely to support bilby populations (Granitic and Rocklea

Land Systems). Survey effort was restricted in the southwest due to cultural avoidance areas, however two of the three most southwest survey plots in this area showed signs of bilbies, suggesting that the area may be well-occupied. Taken together, these detections suggest a broad distribution of occupancy by numerous individuals across much of Tharra. This occupancy is associated with all three major drainage lines (Yule River, Coorong Creek and the Shaw River catchment).

To further delineate and narrow down the priority habitat, a 5 km radius from positive sightings (reflective of upper predictions of daily foraging range), was allocated to each positive detection from track surveys (refer to map 4). Limiting this radius to preferential land systems (Macroy and River Land Systems) within the boundaries of Tharra creates a priority habitat area covering approximately 30,000 ha.

Establish a Baseline Monitoring Approach

The survey methodology employed in the Tharra Greater Bilby Conservation Project was successful in establishing a baseline monitoring approach and generating baseline data for subsequent monitoring of bilby occupancy. Re-implementing the standardised survey and monitoring techniques used in this study will allow comparisons in occupancy over time, with a recommended two year interval between sampling occasions.

The lack of a standardised approach to capturing covariate data on feral predators prevented the effect of feral predators on occupancy to be analysed within the occupancy modelling. Future monitoring should endeavour to standardise the approach and data collection methodology for introduced species within 2 ha plots, as feral predators (cats and foxes) are known to be a major contributing factor to the decline of a range of marsupial populations, including bilbies (Woinarski et al. 2014).

Recommendations for subsequent monitoring include:

- Refining data collection for covariates analysis (fire frequency, introduced herbivores, introduced predators, vegetation cover).
- Introduce remote sensor cameras and image analysis into occupancy analysis.
- Explore the feasibility of abundance analysis and bilby population estimates for the project area.

Key threatening processes

Grazing Pressure

The study shows a significant effect of grazing pressure on bilby presence when covariates were introduced into the model. Specifically, low levels of grazing pressure significantly increased bilby presence (estimate = 2.89, SE = 1.42, z = 2.04, p = 0.04). This aligns with similar findings of correlations between absence or low abundance of livestock and bilby occupancy (Southgate 1990) including at Warralong (Dziminski, Carpenter & Cowan 2021) and in the Kimberley (Dziminski et al. 2021). Disturbances associated with cattle and other large, introduced herbivores are known

to have a negative impact on a range of small to medium-sized mammals in Western Australia (Radford et al. 2015). At Tharra, cattle-related impacts are a major source of cultural and environmental disturbance. Tharra is bordered by three unfenced pastoral stations, and cattle regularly migrate between the many permanent rockholes within the Yule, Shaw and Turner River catchments. Mustering reports from Woodstock provide an indication of cattle numbers within the reserve, with 479 head of cattle removed from Woodstock in 2021, and similar numbers in 2016 and 2017. Other large feral herbivores recorded at Tharra include donkeys, camels and horses (The Budadee Foundation 2015). Importantly, grazing disturbance at Tharra is not uniform, with cattle impacts regularly associated along areas of existing disturbance (such as road and rail infrastructure), standing water, and along river systems (Budadee Aboriginal Corporation, unpublished ranger reports 2022 - 2024).

Predation

Unfortunately, no analysis was undertaken to assess introduced predators on occupancy. Introduced predators are well documented within Tharra, with feral cats, foxes and wild dogs recognised as a threat to Tharra's threatened fauna (The Budadee Foundation 2015) and captured on remote sensor cameras by the Budadee rangers. Foxes and cats are responsible for range reductions and population declines of many native mammals (Burbidge and McKenzie 1989; Woinarski et al. 2011). Fox predation is well established in driving declines of the Greater Bilby and has been implicated as the principal factor in driving regional declines in southwestern Australia (Abbot 2001).

To gain a better understanding of bilby – predator interactions at Tharra, remote sensor cameras were established adjacent to three active burrows. At two of the three camera locations, feral cats were detected waiting outside active burrow sites (see Appendix 2 for examples). Dingos were also captured at two of the three cameras locations, including footage of dingoes attempting to excavate bilby burrows. The relative impact of these species on bilby occupancy at Tharra remains unknown. While feral cat predation is known to limit or extirpate local bilby populations (Woinarski et al. 2014), there is some evidence that bilbies are resilient to some level of feral cat presence (DBCA 2021b). Dingos, while also predating on bilbies, may in fact improve habitat favourability for the Greater Bilby, as they are known to be an important predator of feral cats and may displace fox activity (Southgate and Carthew 2007). While no foxes were captured on any of the remote sensor cameras, their potential impact on Tharra's resident bilbies cannot be ruled out. Foxes have been detected at Tharra on remote sensor cameras during historical surveys and previous ranger fauna monitoring works.

Altered Fire Regimes

During the three-day reconnaissance survey in August 2023 and subsequent field surveys, Palyku knowledge holders provided their assessment on the relative health of bilby habitat across Tharra, as well as the threats to the landscape. Across all the surveyed *baru* country (spinifex flats, best associated with Macroy Land Systems), the relative health of country was deemed to be poor. Developmental pressure (mining and road infrastructure), encroaching weeds, cattle impacts, and feral

predators all contributed to this assessment, but it was the lack of cultural burning that was deemed to be the most significant factor.

To Palyku people, fire is an essential part of the landscape, one that protects nature and culture and fosters connection to Country. Cultural burning was once done at Tharra by Palyku people as they lived on Country. Later, during the Woodstock station days (c 1930s) cultural burning was done as they lived and worked on the sheep station. In the coming decades, fire management at Tharra decreased, with reports in both 1955 (Suijdendorp 1955) and in 1991 (Berry et al. 1991) recommending the re-introduction of active fire management to promote biodiversity. The lack of fire management has resulted in a relatively homogenous vegetation complex of old spinifex across much of the reserve. A buildup of dense vegetation provides excellent kindling for large-scale, hot wildfires that can wreak havoc across the landscape. In 2020, the Budadee rangers recorded approximately 3,000 ha of burnt country from three uncontrolled burns across the reserve. In 2023 an out-of-control fire across the eastern boundary of Tharra damaged the cultural landscape of Tambourah, and an additional wildfire in the southwest of Tharra damaged engravings at a registered cultural heritage site. Altered fire regimes (such as through the loss of Aboriginal burning practices) have been linked to reduced food availability for native fauna (Woinarski et al. 2011), enhanced predation pressure (McGregor et al. 2014) and are recognised as a significant contributor towards the decline of small to medium-sized mammal populations across northern Australia (Lawes et al. 2015*;* Santos et al. 2022*).*

At Tharra, Palyku people teach how a lack of fire has changed the food availability for bilbies. A range of food plants are promoted by a mixture of burnt and unburnt country. This includes *ngarlgu* (bush onions, *Cyperus bulbosa*), bush carrot (*Daucus glochidiatus*), *mungalin* (*Iponoea spp*.), bush bean (*Vigna lanceolata*), *marta* (sweet bush potato, *Dioscorea hastifolia*), *ngarbruda* (bush cucumber, *Cucumis melo*), *galumbu* (*Solanum phlomoides*), *wanyalie* (bush banana, *Marsdenia australis*) and cockroach bush (*Senna notabilis*). Without fire, old spinifex dominates to the detriment of these smaller herbaceous plants that thrive post-fire. Many of these plants are food sources for bilbies and other animals, as well as people. A mosaic of burnt and unburnt country provides food and shelter diversity that supports more animals and helps protect animals against feral predators (Palyku knowledge holders Kevin Stream, Fred Stream and Gavin Cabales, personal comms. August 2023*).*

The positive relationship between bilbies and right-way fire is well established. Bilbies are known to use a mixture of burnt and unburnt country, as well as in different post-fire age vegetation (Southgate 1990). A significant part of their diet is made up of seed from fire-promoted plants (Southgate 19 90; Southgate and Carthew 2007), and bilbies have been documented foraging in areas of post-fire regrowth (Thomson and Thomson 2008), and in recently burnt areas, likely due to the higher availability of fire-promoted food plants (Southgate and Carthew 2007). A heterogeneity of fire age habitat is thought to best meet the habitat requirements for many medium-sized animals by creating a diversity of food availability and shelter from predators (Nimmo et al. 2018).

Conversely, a lack of fire management has been shown to pose a significant threat to bilby populations. A lack of fire may reduce habitat suitability, by both reducing the availability of food from fire-promoted vegetation and reducing bilby movement

through the growth of dense, impenetrable vegetation cover (Bradley et al. 2015). Improper fire management also leads to large-scale, hot fires. These large-scale fires destroy large areas of bilby habitat, reducing food resources and increasing predation risk through a lack of shelter (Dziminski et al. 2020). The local extinctions of two bilby populations in the Pilbara (Pardoo and McPhee Creek) were attributed to large-scale, hot fires in areas lacking any active fire management (Dziminski et al. 2020).

Management Recommendations

Monitoring and Further Research

To effectively assess and manage bilby populations at Tharra, future management should include continued use of standardised 2-hectare plot surveys alongside complementary motion-sensor cameras. These methods provide a consistent approach for monitoring bilby presence and predator activity, which is essential for the ongoing assessment of their population status (Dziminski et al., 2021). Further research is required to understand bilby population dynamics, including the effects and of grazing, predation and fire regimes on their occupancy. Moreover, understanding the genetic diversity of the bilbies in Tharra and the interplay of these external factors will be crucial for informing targeted effective management strategies to support their survival (Woinarski et al., 2015).

Threat Management

Grazing

Grazing pressure, particularly near water sources and riparian habitats, remains a significant threat to bilby populations in Tharra. The presence of cattle, which regularly migrate through the reserve's river catchments, has been identified as a major disturbance to bilby habitat. Collaboration with adjacent pastoralists to reduce grazing pressure, especially near critical areas, would massively mitigate habitat degradation and ensure the availability of food and shelter for bilbies. Evidence from similar studies, such as those by Southgate (1990) and Dziminski et al. (2021), shows that reduced grazing pressure is positively associated with bilby occupancy, making it a priority for management.

Competition with Rabbits

Rabbits, as an invasive species, could pose a competitive threat to bilbies for food and shelter. The presence of rabbits in disturbed areas exacerbates habitat degradation and resource competition. Effective control measures for rabbit populations could be considered as part of ongoing management to alleviate competition and foster bilby recovery. Management practices could include integrated pest control strategies, such as the use of biological agents or targeted trapping (Radford et al., 2015).

Predation

Introduced predators, including feral cats and foxes, are significant threats to bilbies in Tharra (Woinarski et al., 2014). Remote sensor cameras have detected both cats and dingoes near active bilby burrows. While cats have been shown to reduce or eliminate bilby populations in certain areas (Southgate, 1990; Woinarski et al., 2014), dingoes may play a role in regulating predator populations by preying on feral cats and foxes (Southgate & Carthew, 2007). The role of dingoes in managing predator hierarchies should be further studied to understand their potential benefits in bilby conservation, and methods to control feral cat numbers should be strongly considered.

Fire Management

Altered fire regimes, particularly the cessation of traditional cultural burning practices, have been shown to negatively impact bilby habitats (Burbidge & McKenzie, 1989; Cramer et al., 2016). The lack of fire management has led to dense vegetation that reduces food availability and increases the risk of large, destructive wildfires. Reintroducing cultural burning practices in collaboration with Palyku Traditional Owners will restore habitat heterogeneity, promoting a mosaic of burnt and unburnt areas that support bilby foraging and shelter needs (Palyku Elders, 2023; Southgate & Carthew, 2007). This practice has been shown to improve food availability, reduce predation risk, and prevent the spread of large, hot wildfires (McGregor et al., 2014).

Infrastructure

Infrastructure, including roads, fences, and mining operations, poses a threat to bilby populations through habitat fragmentation, increased risk of roadkill, and barriers to gene flow (Bradley et al., 2015). Consideration should be made to investigate the impact of roads and railways on bilby movements and gene flow, particularly near critical habitat areas. Mitigating these impacts could involve the installation of wildlife corridors or underpasses and implementing road safety measures such as wildlife signage and reduced speed limits at dusk/dawn (Northover et al., 2023). Moreover, further studies should explore the cumulative effects of infrastructure, grazing, and fire on bilby habitats.

Habitat Restoration

Habitat restoration is crucial for maintaining and enhancing bilby populations in Tharra. This includes the removal of invasive plant species like buffel grass, which can outcompete native vegetation and degrade bilby habitat (Bradley et al., 2015). Priority areas for restoration should focus on bilby hotspots, especially along river systems where bilbies are known to forage. Replanting native vegetation, such as ngarlgu (bush onions) and munduru roots, will provide vital food sources for bilbies and other native fauna. This restoration work should be guided by ongoing monitoring of vegetation health and habitat suitability, ensuring that restoration efforts align with bilby habitat needs (Woinarski et al., 2015).

Community Engagement

Continued and strengthened engagement with Palyku Traditional Owners is essential to ensure that cultural knowledge is integrated into bilby conservation efforts at Tharra. This report emphasises the importance of traditional ecological knowledge in identifying suitable bilby habitats and monitoring their health (Palyku Elders, 2023). Strengthening partnerships with the Palyku people and enhancing the role of the Budadee rangers in on-Country management will help ensure that conservation efforts are both scientifically sound and culturally appropriate. Expanding ranger capabilities through training in predator control, habitat restoration, and monitoring will empower the local community to play a pivotal role in bilby conservation (Southgate & Carthew, 2007).

Education

Raising public awareness about the ecological and cultural significance of bilbies is essential for their conservation into the future. This report stresses the need for public education programs to foster a deeper understanding of bilby ecology, their role in the Pilbara ecosystem, and the cultural importance of bilbies to the Palyku people. Education initiatives could include outreach programs, workshops, and partnerships with schools to engage local communities in bilby conservation. Promoting the 'Easter Bilby' chocolate bilby on an international level, instead of the traditional 'Easter bunny,' could massively help raise awareness of the bilby's conservation status (Veríssimo, 2017). Increased public awareness will help build a sense of ownership and stewardship, which is critical for the long-term success of conservation efforts.

Policy and Funding

Advocacy for sustained government support and funding is critical to the success of bilby conservation at Tharra. This report highlights the importance of integrating the findings from this study into broader policy frameworks to ensure that conservation efforts are adequately supported (Dziminski et al., 2021). Securing funding for long-term monitoring, habitat restoration, and predator control will help ensure that bilby populations are maintained and supported across the region. By aligning local, state, and national policies, a coordinated approach can be developed to support evidence-based conservation strategies for the Bilby (Woinarski et al., 2015).

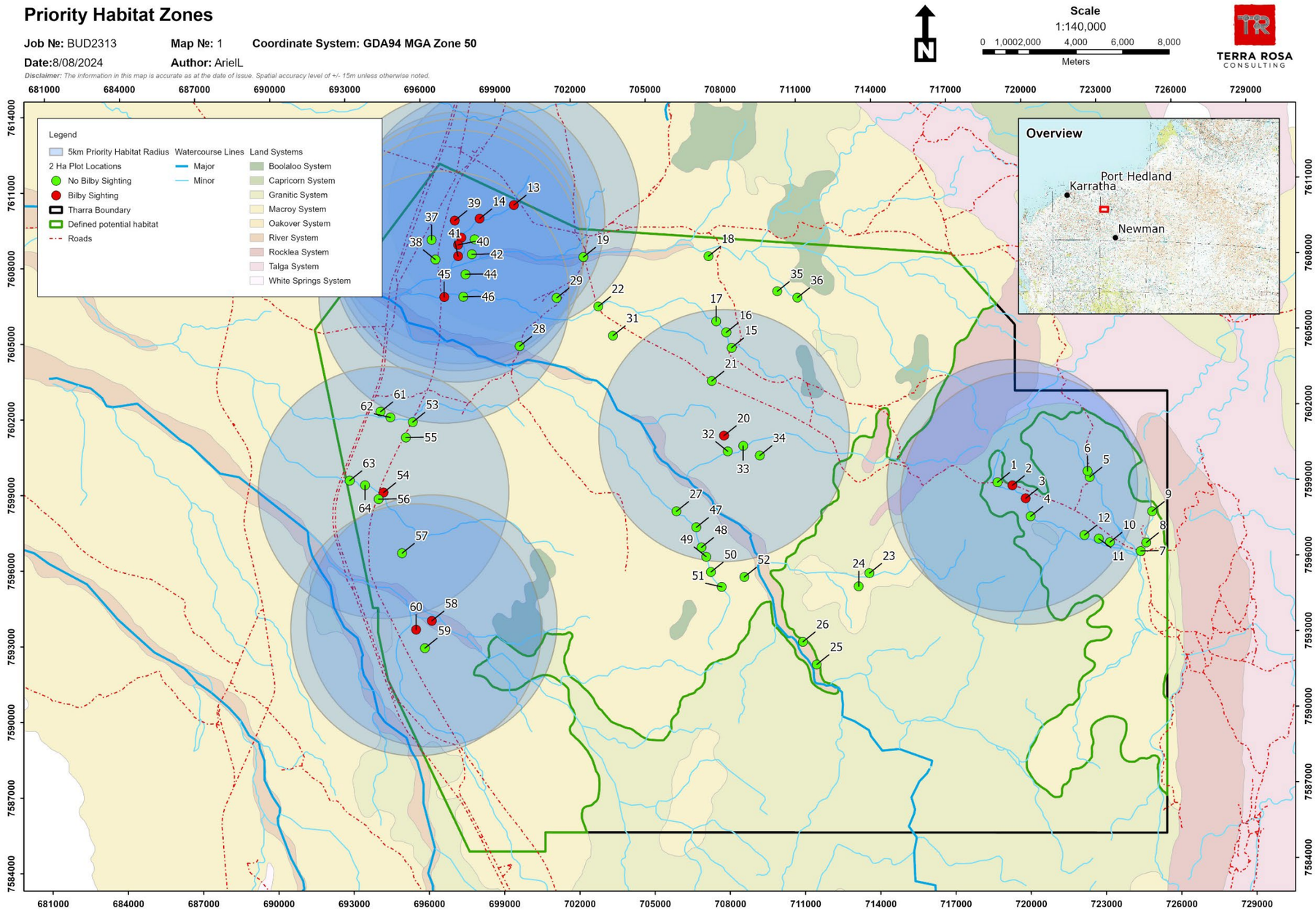
These management recommendations, informed by both scientific data and traditional knowledge, provide a comprehensive approach to bilby conservation at Tharra. Implementing these strategies will ensure the long-term survival of the Greater Bilby in the Pilbara region.

Conclusion

Tharra is well positioned to be an actively managed refuge for Greater Bilby populations in the central Pilbara. As part of the greater Woodstock Abydos Protected

Reserve, Tharra receives protection under section 19 of the *Aboriginal Cultural Heritage Act 2021 (WA)*, safeguarding it from future activities common to the region, particularly pastoral and mineral resource sectors. It also benefits from active cultural and environmental management through the Budadee ranger program, who routinely undertake Caring-for-Country management across the reserve. Tharra contains large tracts of habitat suitable for bilbies, alongside historic recordings of Greater Bilbies dating back to the 1960s. Results of the occupancy analysis confirm that bilbies are indeed still present across the reserve, with sighting from multiple locations, some separated by more than 20 km. A baseline monitoring approach has been established, and the high level of detectability provides confidence in the ability of the Budadee rangers to undertake effective bilby monitoring into the future. A range of threats to bilby habitat at Tharra were identified during the survey, including introduced predators, large, introduced herbivores, developmental pressure, altered fire regimes, and encroaching weeds. Of these threats, Palyku knowledge holders identified the lack of cultural burning as the most significant factor affecting the health of bilby habitat, and the primary contributing factor to the poor health of *baru* country (spinifex flats). Introduced predators (feral cats) were detected by remote sensor cameras at active bilby burrows. Occupancy analysis illustrated that low grazing pressure was positively associated with bilby occupancy. This aligned with the results of other bilby occupancy studies and suggests that large feral herbivores pose a significant threat to bilbies and bilby habitat. A comprehensive list of management recommendations, informed by both scientific data and traditional knowledge, are included in this report which provide a holistic approach to bilby conservation at Tharra. Implementing these management recommendations will contribute to the long-term survival of the Greater Bilby in the Pilbara region.

Map 4: 5 km priority habitat zone radius centred on confirmed sightings of bilbies within Tharra.



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Appendix 1: Plot Photos

Appendix 2: Remote sensor camera images.

Plate 1: Remote sensor camera set up in front of active bilby burrow.

Plate 2: A bilby captured on remote sensor camera within WAPR on 27 July 2024.

Plate 3: A bilby captured on remote sensor camera within WAPR on 6 June 2024.

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Plate 4: Bilby leaving burrow on 11 August 2024.

Plate 5: Dingo excavating the same bilby burrow on 12 August 2024.

Plate 6: A feral cat captured investigating bilby burrow on 15 August 2024.

Plate 7: Cattle activity at Tharra Pool on 25 July 2024.

Appendix 3: Desktop Research

Appendix 4: Project contacts

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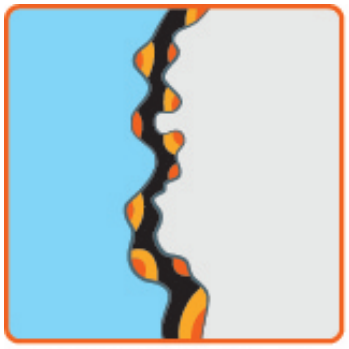
Version Control

Version	Date	Change log	Author(s)
0.1	21/02/245	Draft document	Callum Warhaup
0.2	26/2/25	BAC Review	Josie Huck
0.3	06/03/25	Final	Mat Oliver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